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THE RUBBER INDUSTRY

BEING THE OFFICIAL REPORT OF THE FOURTH INTERNATIONAL RUBBER CONGRESS HELD IN LONDON IN 1914, TOGETHER WITH THE PAPERS READ, AND THE DISCUSSIONS THEREON

NUMEROUS PAPERS AND DISCUSSIONS DEALING WITH FIBRES, COTTON, OILS, ETC.

THE PRINCIPAL PAPERS READ AT THE RUBBER CONGRESS, NEW YORK

ALSO A REPORT OF THE PROCEEDINGS OF THE FOURTH INTERNATIONAL RUBBER AND ALLIED INDUSTRIES EXHIBITION, LONDON, 1914

EDITED BY

JOSEPH TORREY, Ph.D.

AND

A. STAINES MANDERS

PUBLISHED BY
THE INTERNATIONAL RUBBER AND ALLIED TRADES EXHIBITION, LTD.
75, CHANCERY LANE (HOLBORN), LONDON, W.C.

15/6 NETT.

To my friend,

SIR HENRY A. BLAKE, G.C.M.G.,

President of the International Rubber Congress, 1914,

with the sanction

of my Co-Editor, Dr. Joseph Torrey,

I dedicate this publication.

A. STAINES MANDERS.

FOURTH INTERNATIONAL

RUBBER CONGRESS

HELD IN LONDON,

June-July, 1914.

President—

SIR HENRY A. BLAKE, G.C.M.G.

Chairman—

JOSEPH TORREY, Ph.D.

Vice-Chairmen—

JOHN McEWAN, ESQ. (Chairman, Rubber Growers' Association).

ARTHUR LAMPARD, ESQ. (Messrs. Harrisons & Crosfield, Ltd.).

PROF. PERROT (Ecole Superieure de Pharmacie, Université de Paris).

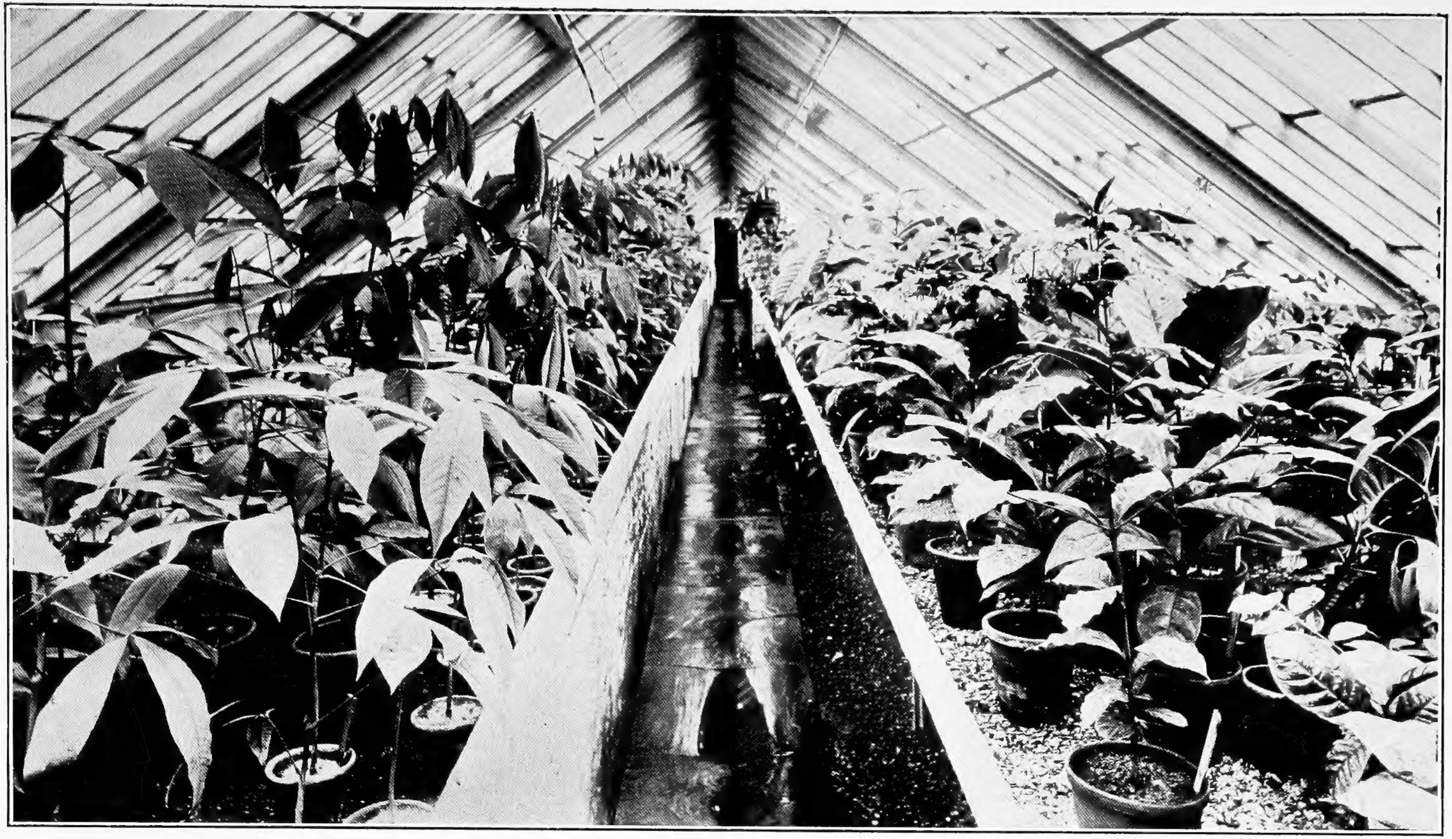
CYRIL BAXENDALE, ESQ. (Representing the Planters' Association of the Federated Malay States).

PHILIP SCHIDROWITZ, ESQ., Ph.D.

ALEXANDER JOHNSTON, ESQ. (North British Rubber Co., Ltd.).

F. PEGLER, ESQ. (Northern Rubber Co.).

A. STAINES MANDERS.



The tropical propagating pit, or glasshouse, at Kew Gardens, where the first seedlings of Para rubber (Hevea brasiliensis) were raised. The house is still used for the raising of rubber and other plants of economic value to the Colonies. The photo gives a good idea of the appearance of the house 40 years ago.

(*The photo shows a group of Heveas on the left, and species of coffee and cocoas on the right hand side.*)

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PREFACE.

THIS volume will speak for itself, but the Editors believe that those interested in the Rubber Industry, and students who may study the papers and discussions contained therein, will find that it contains most valuable information relating to the vast industry. The papers dealing with cotton, fibres, etc., which go hand in hand with rubber, added greatly to the interest of the meetings, and should enhance the usefulness of this, their permanent record.

CONTENTS.

Part I.

CHAPTER I.

Opening of the Congress. Sir Henry A. Blake, G.C.M.G.

Introduction :—Historical and Descriptive Synoptical Tables of the Different Varieties of Commercial Rubber. By Dr. D. Spence. Specially written for this publication.

Part I.

CHAPTER II.

PAGES.
The Systematic Study of Rubber Production. By R. N. Lyne, F.L.S., F.R.G.S., Director of Agriculture, Ceylon .. .. 35 to 44
A Comparison between Wild and Plantation-grown Rubber. By A. Irving .. .. 45 ,, 57
Some Notes on the Manuring of Rubber. By H. Hamel Smith, *Tropical Life* .. .. 58 ,, 70
Rubber Plantation in Angola, Portuguese West Africa. By C. de Mello Geraldes .. .. 71 ,, 74
Rubber Cultivation in Cochin China. By Andre Cremazy, Ex-President of the Chamber of Agriculture, Cochin China .. .. 75 ,, 83
Kelantan as a Rubber Producer. By T. Clifton Hutchings, Chairman, Kelantan Planters' Association .. .. 84 ,, 86
Cultivation of Rubber-growing Vines in Central Africa. By E. de Wildeman, Botanic Gardens, Brussels .. .. 87 ,, 95
Notes on the Philippine Rubber Question. By O. W. Barrett, Bureau of Agriculture, Philippine Islands .. .. 96 ,, 100
The Best and Most Economical Methods of Tapping. By W. F. de Bois Maclaren .. .. 101 ,, 113
Notes on the Physiology of the Latex Production in Hevea. By R. H. Lock, Sc.D., F.L.S., Late Director of Agriculture, Ceylon .. 114 ,, 123
Observations on, and Comparative Tests of, the Latex of Wild and Plantation Hevea. By Felix Ripeau, Paris .. .. 124 ,, 129
The Coagulation of the Latex of the Hevea Braziliensis, and its Bearing on the Strength of Rubber. By Newton W. Barritt, B.A., International Institute of Agriculture, Rome .. .. 130 ,, 136
The Chemical Coagulation of Rubber Latex. By Frederick Kaye, A.R.C.Sc. .. .. 137 ,, 143
The Proteids in Caoutchouc and in Latex. By Dr. Fritz Frank, Berlin .. .. 144 ,, 148
On the Depolymerisation of Raw Rubber. By A. van Rossem, Netherlands Experimental Station .. .. 149 ,, 155
Contribution to the Study of Rubber Solutions Vulcanised by the Ultra-Violet Rays. By A. Helbronner, D.Sc., Paris .. .. 156 ,, 163
Vulcanisation. By Gustave Bernstein, D.Sc., Manager, Torrilhon Factory, Clermont-Ferrand, France .. .. 164 ,, 171
The Mass Action of Sulphur in Vulcanisation. By H. Skellon, B.Sc., Chief Chemist, Wood-Milne, Ltd. .. .. 172 ,, 180
The Estimation of Bitumen in Rubber Mixings. By B. D. Porritt, B.Sc. (Lond.), F.I.C., Chief Chemist; and E. Anderson, A.I.C., Chemist, North British Rubber Co., Ltd. .. .. 181 ,, 189
On the Use of Nitric Acid as a Solvent for Compounded and Vulcanised Rubbers. By Henry Williams Jones, Chemist, Dunlop Rubber Co., Ltd. .. .. 189 ,, 190
A Method of Estimating Small Amounts of CO_2 in Presence of Sulphides. By Henry Williams Jones, Chemist, Dunlop Rubber Co., Ltd. .. .. 191 ,, 192

PAGES.

Experiments on the Determination of Mineral Matter in Rubber Mixings. By B. D. Porritt. B.Sc. (Lond.), F.I.C., Chief Chemist; and R. Wheatley, B.Sc. (Leeds), A.I.C., Research Chemist, North British Rubber Co., Ltd. .. .. 193 to 199

A Simple Method for the Estimation of Mineral Matters in Vulcanised Rubbers. By Henry Williams Jones, Chemist, Dunlop Rubber Co., Ltd. .. .. 199 ,, 204

The Effects of Acids and Alkalies on Rubber, more Especially in Relation to Reclaimed Rubber. By W. G. Martin, Experimental Dept., North British Rubber Co., Ltd. .. .. 205 ,, 211

Variability. By Philip Schidrowitz, Ph.D., F.C.S. .. .. .. 212 ,, 229

Some American Methods of Testing Mechanical Rubber Goods. By D. E. Douty, General Manager, United States Conditioning & Testing Co., New York City .. .. 230 ,, 245

The Influence of Temperature on the Tensile Properties of Rubber Compounds. By P. L. Wormeley, United States Bureau of Standards .. .. 246 ,, 258

Rubbered Balloon Fabrics. By Guy Barr, B.A., B.Sc., National Physical Laboratory, England .. .. 259 ,, 275

Synthetic Rubber (Researches on the Commercial Preparation of Isoprene). By Gaston Chardet, Paris .. .. 276 ,, 279

Substitutes Derived from Oxidized Oils. By Gaston Chardet, Paris. 280 ,, 283

The Advantages and Defects of Plantation Rubber. By W. A. Williams, General Works Supt., North British Rubber Co., Ltd. 284 ,, 297

Some Aspects of Plantation Rubber. By E. L. Killick .. .. 298 ,, 302

Bonus Schemes for Managers and Assistants on Plantation Rubber Estates. By P. J. Burgess .. .. 303 ,, 310

Rubber Production Costs. By Cyril Baxendale, Jugra Estate, F.M.S. 311 ,, 316

Increasing the Yield of Funtumia Elastica or "Lagos Silk" Rubber. By Edm. Leplae, Director-General of Agriculture of the Belgian Congo .. .. 317 ,, 318

A Practical and Cheap Method for Determining the Fertility of Rubber Soils. By E. Leplae, Professor at the Louvain University, Director-General of Agriculture of the Belgian Congo .. .. 318 ,, 321

Invention and its Relation to the Rubber and Textile Industry. By J. Victor Armstrong, Registered Patent Agent; and Harold E. Potts, M.Sc., Chartered Patent Agent .. .. 322 ,, 328

Full Report of The Conference of Manufacturers and Planters .. 329 ,, 338

Part I.

CHAPTER III.

PAGES.

Names of Textile Plant Fibres. By Lyster H. Dewey, Botanist-in-Charge of Fibre Investigations, United States Department of Agriculture .. .. 341 to 350

Fertilising Cotton in the United States. By Ockononiscrat E. Lierke, Berlin .. .. 351 ,, 359

Problems of the Future Conditions of the Palm Oil Industry. By L. C. Gatin, D.Sc., Agricultural Engineer, Chief of the Laboratory of Tropical Agronomy, Paris; Secretary of the "Journal d'Agriculture Tropicale," Paris .. .. 360 ,, 364

Vote of Thanks to the Chairman (Dr. Joseph Torrey) 365

Part II.

CHAPTER I.

NEW YORK RUBBER CONGRESS.

(*See page* 368.)

DISCUSSIONS.

Pages
- Arndt, Dr. .. 188, 244
- Bagnall, F. A. .. 312, 315
- Barbary, Ewart .. 100, 189, 358, 359, 364
- Baxendale, C. .. 67, 68, 301, 320, 321, 363, 364
- Bethune, A. .. 336
- Bevis, H. .. 337
- Bingley, Noel .. 336
- Blake, Sir Henry A. .. 123
- Boustead, Mr. .. 336
- Bruce, A. .. 42, 68, 141
- Burgess, P. J.—41, 42, 100, 136, 168, 226, 227, 243, 296, 337
- Burnard, R. .. 66, 68, 135, 211
- Cadell, H. M. .. 67
- Crosbie-Roles, F. .. 42
- Cumming, Malcolm .. 331
- Dessau, M M. .. 332
- Douty, D. E. .. 244, 256, 257, 258
- Edmed, F. G. .. 203, 204
- Esch, Werner—56, 134, 135, 152, 154, 188, 202, 203, 204, 210, 211, 226, 228, 229, 257, 258, 272, 273, 274
- Gardner, J. C. .. 313
- Gatin, Dr. L. C. .. 363
- Gibson, W. T.—42, 69, 95, 122, 123, 136, 142, 147, 148, 154, 168, 169, 170, 178, 179, 244, 258, 257, 274, 296
- Golledge, G. H. .. 112, 113, 121
- Helbronner, Dr. .. 167, 168, 169, 170, 171
- Hodgman, G. B. .. 336
- Hughes, W. H. .. 336
- Irving, A. .. 334
- Kaye, F. .. 141, 142, 274
- Koenig Heinrich .. 55, 363
- Leplae, Ed. .. 302, 320, 321, 363, 364

Pages
- Lierke, Dr. .. 358, 359
- Lock, R. H. .. 42, 122, 123
- Loewen, Dr. .. 170, 171, 179, 180, 211
- Lyne, R. N. .. 43, 68
- Maclaren, W. F. de Bois .. 40, 112, 113
- MacLulich, J. W. .. 334, 337
- Magor, Richard .. 333, 334, 337
- Martin, W. G. .. 153, 210, 211, 256
- McEwan, John .. 310, 313, 314, 315, 335, 338, 365
- Memmler, K. .. 243
- Morrison, Stanley .. 330, 333, 334, 337, 338
- Perrot, Prof. Emile .. 264
- Pickles, Dr. .. 188, 202, 358
- Porritt, B. D.—55, 168, 188, 189, 193, 204, 256, 273, 274
- Ramsay, Sir Wm. .. 167
- Rossem, A. Van .. 152, 153, 154, 155
- Schidrowitz, Philip—132, 135, 226, 227, 228, 229, 245, 332
- Skellon, H. .. 177, 178, 179, 180
- Slocum, E. M. —56, 57, 66, 67, 123, 129, 134, 141, 147, 153, 168, 170, 180, 203, 210, 272, 273, 278, 279, 283
- Smith, H. Hamel .. 69, 122, 123
- Stevens, Henry —111, 129, 141, 178, 245, 294, 331, 332
- Torrey, Joseph .. 365
- Thompson, D. J. .. 177, 178, 227
- Thompson, K. J. .. 134
- Whitby, Stafford—54, 55, 56, 129, 147, 148, 152, 258, 363
- Watson, E. D. .. 315
- Welldon, C. E. .. 334
- Wickham, H. A. .. 294
- Williams, W. A. .. 225, 228

ILLUSTRATIONS.

Pages
- American Methods of Testing Mechanical Rubber Goods .. 232 to 242
- Contribution to the Study of Rubber Solutions Vulcanised by Ultra-Violet Rays .. 157 to 162
- Effect of Acids and Alkalies on Rubber, etc. 207 & 209

Pages
- Influence of Temperature on the Tensile Properties of Rubber Compounds .. 247 to 252
- Mass Action of Sulphur in Vulcanisation 174 to 176
- Method of Estimating Small Amounts of CO_2 in Presence of Sulphide .. 191
- Rubber Plantations of Angola ("Santos" Inciseurs) 72

Official Commissioners and Delegates to the Exhibition .. 456

FUNCTIONS.

Pages
- Distribution of Awards .. 497 to 506
- International Rubber Banquet .. 464 to 483
  - Argollo, Dr. Jayme de .. 481
  - Barrett, A. O. .. 468
  - Baxendale, Cyril .. 471
  - Blake, Sir Henry .. 465, 475, 483
  - Browne, Miss Edith A. .. 479
  - Grieve, Norman .. 469
  - Johnston, Alexander .. 472
  - Lampard, Arthur .. 474
  - Leplae, Ed. .. 468
  - Lyne, R. N. .. 482
  - Mendes, J. A. .. 471
  - McEwan, John .. 477
  - Pegler, F. .. 473
  - Pfaff, E. F. .. 481
  - Perrot, Emile .. 467
- Opening Ceremony .. 459 to 463
  - Blake, Sir Henry .. 459
  - Connaught, Prince Arthur .. 460
  - Harcourt, The Right Hon. Lewis .. 461
  - McEwan, John .. 462
  - Good Wishes by Cable .. 463
- Presentations .. 494 to 496
  - Blake, Sir Henry .. 494
  - Fulton, Miss D. .. 494, 515
  - Manders, A. Staines .. 494, 515
- Press View .. 484 to 488
  - Argollo, Dr. Jayme de .. 487
  - Blake, Sir Henry .. 484
  - Fitz-Gibbon, Dermot .. 487

Pages
  - McEwan, John .. 485
  - Smith, Theodore E. .. 487
- Sir Henry and Lady Blake's Reception .. 462
- Special Meetings, Other Functions, etc. .. 507 to 516
  - Belgian Day .. 509
  - Brazil Day .. 507
  - Brighton Visit .. 509
  - Ceylon Day .. 511
  - "Financier and Bullionist" Lunch .. 507
  - French Day .. 511
  - Guatemalan Reception .. 514
  - Malay Day .. 508
  - Rubber Companies Receptions .. 516
  - Rubber Growers' Association Reception .. 512
  - Sao Paulo Day .. 513
  - Sudan Day .. 513
  - Visit of Her Royal Highness Princess Marie Louise of Schleswig-Holstein .. 510
  - Visit of the Lord Mayor and Sheriffs .. 508
  - Visit of His Excellency the Governor of Portuguese West Africa .. 508
- West India Committee Dinner .. 489 to 493
  - Anderson, Wilgress .. 491
  - McKinstry, W. L. .. 492
  - Nicholls, Alford .. 492
  - Phillips, Sir Owen .. 489, 491, 493
  - Rutherford, Robt. .. 493
  - Sands, W. N. .. 493
  - Shackleton, Sir Ernest .. 490
  - Tempany, H. A. .. 493

Permission for the publication of any of the papers, discussions, or articles appearing in this work, cannot be given.

A. STAINES MANDERS.

Part I.

CHAPTER I.

Opening of the Conference.

Introduction—Historical and Descriptive.

Opening of the Congress.

Tuesday, 30th June, 1914.

Address by the President.

The Fourth International Rubber Congress opened on Tuesday, June 30th, under the presidency of Sir Henry A. Blake, G.C.M.G., who said:—

The Fourth International Conference under the auspices of the International Rubber Exhibition, for which we are assembled to-day finds us face to face with the same problems with which we dealt in 1908 and 1911; but we enter upon their consideration with the accumulated experience of three more years, during which the theories and statements put forward and discussed at the two previous conferences have been tested in the field and the factory.

In the Exhibition we can examine the fruits of the industry, but here our examination is directed to its roots, and the papers to be presented for discussion at our conference cover almost the entire ground until the raw rubber has entered into the ultimate processes of manufacture.

I mentioned in my address to the conference in 1908 that the plantations then being established with so much energy, owing to the rapidly increasing demands of the motor industry could not be expected to come into full bearing before 1913 at the earliest, and that the returns on the extensive plantations made in 1910 would not be known before the present year. There is reason to believe that some of the plantations made at that period of investing excitement have been found to have been made under unsuitable conditions as to climate or situation, but the fact remains that the production of plantation rubber from the East was 48,000 tons, and the total production of the world's rubber was 108,440 tons for the year 1913, as against 65,400 tons in 1908.

This is a considerable increase, but the demand has increased in at least equal proportion. Apart from the improvements in the quality of plantation rubber that we may expect from the work of the chemist and botanist, and the experience of the planters, the main issue for those who have invested in the industry is the question of supply and demand, and in the consideration of these problems the broad fact must stand out that while there must be a limit to supply, which is governed by suitable conditions for the economic propagation of the rubber-bearing trees, and the supply of labour, the possible demand for rubber may, in certain eventualities, be practically unlimited.

In my address at the opening of the conference of 1908 I find the following passage: "I have known many people to laugh at the idea of such an extension in the use of rubber as its being devoted to the paving of our streets; yet men who know their business, experts, who understand all the details of manufacture, have assured me that such a utility is within the possibilities, and that with rubber at a moderate price it would be able to compete successfully with quarries for such a purpose."

To-day you will find shown in this exhibition three systems for street paving, that claim practical economy in its use at present prices over the ordinary wooden pavement. I observe that *The Times* decries such a use on account of the obliteration of the noise of approaching vehicles, and thereby endangering pedestrians. This is the adoption of the principle on which the Chinese leaves the wooden axle of his wheelbarrow ungreased so that the noise may give warning of its approach; but I do not consider the objection insuperable, while the adoption of rubber for such a purpose would create a demand that could not be satisfied for many years.

Our desire in this Conference is the acquisition of knowledge, and the frank interchange of ideas. To the rubber planter, future prosperity can best be secured by such improvement in plantation management as will reduce the cost of production. That cost has been steadily decreasing, but there is still a considerable margin for possible saving in the cost of producing and marketing plantation rubber.

I observe with pleasure that among the papers to be read and discussed are three on the subject of synthetic rubber. Whatever planters may feel about the possible competition of synthetic rubber, there is nothing to be gained by ignoring it. It may be that synthetic rubber equal to good plantation can be produced; in my opinion it is extremely improbable. But if it be so we must face the competition strong in the conviction that Nature works more cheaply than any probable synthetic exploitation on a large scale. Anyhow, it would take some years to test its durability and the continuance of its resilient and tensile properties before manufacturers could safely accept it as a guaranteed substitute for rubber. Even if it were ultimately proved to possess all the requisite qualities, the coming use of rubber for the pavement of streets and paths, to which I look forward with some confidence, and for the flooring of churches and public and private buildings, would demand all the rubber that could be produced by Nature or Art.

The standardising of rubber is another question that calls for careful consideration. Granting its advisability from the market point of view, its adoption would involve drastic changes in the management of the smaller estates and factories.

All these matters I commend to the Delegates who have done us the honour of attending this Conference. Many of whom I am happy to meet again as old friends, and to all of whom I offer a cordial and most hearty welcome.

The details of the consideration of the papers has been carefully arranged by Dr. Torrey, and I venture to suggest in view of the number of papers to be got through that gentlemen taking part in the discussions will as much as possible limit their observations to ten minutes.

There was a large attendance, and amongst those present were:—Sir Henry A. Blake, Viscount de Pedralva, Sir William Ramsay, Professors Emile Perrot, Ed. Leplae, Carlos de Mello Geraldes, Karl Memmler, Doctors Joseph Torrey, Philip Schidrowitz, Jayme do Argollo (Junr.), F. Arndt, G. Bernstein, Theodoro Braga, Sousa Castro, Werner Esch, C. L. Gatin, A. Helbronner, Taiji Komuro, E. Lierke, R. H. Lock, H. Loewen, H. A. Alford Nicholls, Cerqueira Pinto, E. M. Slocum, H. P. Stevens, K. J. Thompson, Jose Rodrigues Vieira, Warburg, Colonel Raymundo P. Brazil, Colonel L. de Mattos, Capt. Commandant Leon

Osterrieth, Messrs. C. W. Anderson, Jayme P. da Gama Breu, F. A. Bagnall, R. Burnard, Newton W. Barritt, E. J. Byrne, B. Bysow, J. Ewart Barbary, Henri Braeckman, O. W. Barrett, Cyril E. S. Baxendale, R. Besley, Guy Barr, P. J. Burgess, F. Crosbie-Roles, Andre Cremazy, Gaston Chardet, Morland M. Dessau, D. E. Douty, S. C. Davidson, F. G. Edmed, J. G. Fol, Francois, G. H. Golledge, W. T. Gibson, P. Holfte, G. B. Hodgman, T. Clifton Hutchings, A. Irving, Alexander Johnson, H. W. Jones, W. H. Johnson, E. L. Killick, H. Koenig, W. Kappler, C. D. Kennedy, Kaichi Kawakami• Frederick Kaye, R. N. Lyne, John McEwan, W. F. de Bois Maclaren, Jose Amando Mendes, W. L. McKinstry, A. Stanley Morrison, Harold S. Miller, W. Martin, C. O. Macadam, W. G. Martin, Paul Osterrieth, B. D. Porritt, A. Pedler, F. Pegler, E. F. Pfaff, Felix Ripeau, Carlos Rabbi, E. G. Salmon, Arthur Schopper, H. E. G. Solbe, H. Hamel Smith, Herbert Skellon, Harold A. Tempany, W. Vaas, H. Vuillet, N. H. Witt, Henri Woog, G. Stafford Whitby, H. A. Wickham, J. V. Worthington, A. Staines Manders, Miss D. Fulton and a large number of others.

Dr. Joseph Torrey, as Chairman of the Congress, subsequently took charge of the proceedings.

The CHAIRMAN: Now, gentlemen, on the occasion of the last Congress there were some observations at the close, as to the procedure. I think possibly it might be more convenient, if any gentleman has anything in his mind that he considers might be useful in connection with the work of the Congress, that he should let us have his observations now. We might be guided to a certain extent by them.

No questions of the kind being raised, the Congress adjourned until the afternoon.

Introduction.

Historical and Descriptive.

By

Dr. D. SPENCE.

The word india-rubber, which is still almost exclusively used in English, was first applied to that substance which the Indians on the banks of the Amazon called *cahuchu*. This substance was found by the English scientist Priestley, in 1772, to have the power of removing pencil marks from paper, and as this was for long almost the only, if a not unimportant, use to which the substance was put, it is perhaps not surprising that the word india-rubber found access to our language and has been generally accepted.

The word caoutchouc, on the other hand, which is obviously derived from the native name, was also introduced to denote the same elastic substance as india-rubber. This word, however, has found only a limited application in English, although in other languages it alone is used. In English the word caoutchouc has come to be looked upon as denoting the pure rubber hydrocarbon, while india-rubber is a general term for the crude product, whether raw or manufactured. The advantage of this distinction has been fully borne out by the developments in recent time in connection with the synthesis of india-rubber from elementary organic substances.

The first European to become acquainted with india-rubber appears to have been Christopher Columbus. At all events, Antonio de Herrera, the historian, states of him that on his second voyage of discovery to America in the years 1493–1496, he saw the inhabitants of Haiti playing with balls which, he afterwards learned, were prepared from the *gum of a tree*. In 1535, and before Herrera, Gonzalo Fernandez de Oviedo y Valdez reported on elastic balls which the Indians used in their games, and, even ten years before that, Pietro Martyr d'Anghiera had introduced india-rubber into our literature without naming it. In the year 1615, Juan de Torquemada issued a report in regard to a tree from which the inhabitants of Mexico extracted a milky liquid which the Spanish invaders afterwards used to make their garments water-proof. It would take one too far afield to trace down the various reports published, from time to time, in regard to this curious product which gradually became better known in our country as india-rubber, and for which several uses were soon suggested by practical men. It was not, however, until after the important discovery of vulcanisation by Goodyear that india-rubber came to be looked upon as a natural product of great commercial value, and that a means of utilising it became known. Indeed, it may safely be said that, but for the results of vulcanisation, the india-rubber industry would never have risen to be what it is now.

The india-rubber of commerce is derived from the milky secretion, known as latex, of certain tropical and sub-tropical trees and vines found indigenous in America, Africa and the Indo-Malay regions, and now cultivated extensively in Ceylon and the Far East. When these rubber-yielding plants are injured by excising the bark or by tapping, as it is called, or in some such way, a more or less thick milky-looking fluid is found to exude from certain parts of them. This fluid, which resembles milk probably more closely than has been hitherto believed, varies in density with the source from which it is collected and with the amount of caoutchouc and other substances contained in it.

The latex, when examined under the microscope, is found to be an emulsion of very minute, oil-like, refractive globules, varying in size, which are in a state of rapid Brownian movement in a clear watery liquor known as the serum. When sections of the latex-producing plant are prepared and examined under the microscope, one finds in general that the latex is confined to certain well-defined, but peculiar, canal-like structures known as latex vessels, which are distributed in a perfectly definite manner throughout certain parts of the plant. The arrangement of these latex tubes varies very considerably in different plants. It is hardly necessary, therefore, to point out how much of the success in the "tapping" of rubber trees depends on the rational application of scientific information in regard to the distribution of the latex system in the plant.

When properly collected the latex should be entirely free from such impurities as bark, vegetable fibre and sand, which one so often finds in rubbers prepared by the primitive methods of the natives. The latex of the various rubber-producing plants is usually stated to be neutral or faintly alkaline; sometimes it has been said to be acid, but the correctness of this assertion is doubtful. Probably it is amphoteric, or faintly alkaline, like most physiological fluids involved in metabolic processes, and on the maintenance of this reaction may depend its whole usefulness in the economy of the plant. In vitro, however, the reaction of the latex quickly changes, becoming markedly acid. The acidity which develops in fresh latex on standing is analogous to the souring of milk, and is brought about by similar agencies.

When the latex is submitted to chemical examination one finds that it is not merely an emulsion of fine particles of caoutchouc in water. Every latex which yields rubber may be said to contain, besides caoutchouc, the globules which give the latex its milky appearance, varying quantities of other chemical substances, such as resins and protein (the distribution of which in the latex is not yet completely understood), and organic substances such as sugars, alkaloids and salts of acids such as malates, sulphates, phosphates and chlorides. The quantity of these various substances, associated with the true rubber substance in the latex, varies with the botanical source of the latter and with the age of the tree from which the latex is obtained. Thus it has been shown that resins, proteins, and sugars are present in greater amount in the latex from young trees than in that from trees fully matured. In this same connection the presence in the latex of active substances, known as enzymes, must also be noted on account of their great importance, commercially in connection with the preparation of india-rubber, and physiologically on account of their function in metabolic processes. It is these enzymes that are largely responsible for the acidity which develops in fresh latex on standing. To their presence also, the spontaneous coagulation of latex, and the rapid darkening in colour which occurs in raw rubber after its preparation, must be largely attributed. If these enzymes are destroyed by sterilising the latex, the rapid souring and coagulation of the latter, which would otherwise occur, is very largely prevented. In the same way, if these enzymes, or the substances on which they act, are removed from the latex by any means, the rubber prepared from this latex will remain permanently white. Advantage has been taken of these facts in the preparation of the plantation rubber now coming in large quantities from the Far East.

The amount of caoutchouc which can be obtained from a given quantity of latex depends on the source of the latex, on the age of the tree from which it is collected, and on the part of the tree from which it is taken, as well as on the external conditions affecting the metabolism of the tree. In the same way the amount of latex collected from a tree depends on a great many factors at present only imperfectly investigated. Obviously, therefore, a very great many things must be taken into account if we are to collect useful and reliable data in regard to the "bearing capacity" of a rubber tree. This has been only too frequently overlooked.

India-rubber is the dried-up or coagulated latex. Until recently the methods employed for coagulation have been very numerous and often very primitive. The method adopted has, nevertheless, a very important bearing on the physical properties of the resulting rubber. By scientific methods, the quality and the value of the poorer brands of rubber have been very much improved.

It is impossible to enter here into an account of the current views in regard to the subject of coagulation. It is much too complicated a topic to admit of treatment in such a review as this, and much still remains to be discovered. As the practical value, however, of a sample of rubber depends so largely upon its method of preparation, we cannot but refer briefly to some of the methods employed.

METHODS OF PREPARATION OF RAW RUBBER.

1.—By heat.
  - (*i*) By artificial heat.
    - (*a*) Dry heat or smoking: In Brazil and on the Amazon, and recently in the Far East.
    - (*b*) Moist heat or boiling: In Mexico and in West Africa for *Funtumia elastica* and other latices.
  - (*ii*) By natural heat: In various parts of Africa, etc.

2.—Coagulation by chemical means.
  - (*a*) Organic acids and extracts of plants, etc.: In Ceylon and the Far East; also in Peru, Guatemala, Gambia, Madagascar, Upper Congo, etc.
  - (*b*) Mineral acids and mineral reagents: In Gambia, Senegal, Mozambique, Matto Grosso, Pernambuco, Maranhao.

3.—By beating and maceration: In West Africa and German East Africa and Madagascar, and in Mexico for "Guayule" rubber.

Of all these methods only two are of practical importance to-day, namely that by artificial dry heat or smoking, and that by organic acids. By these two methods almost the entire world's rubber is prepared, and their importance is fast increasing. The changes which have taken place within the past five years, owing to the rapidly increasing production of so-called Plantation Rubber in the Far East, are fast rendering obsolete, practically, all other methods of preparation. In a few more years most of the older brands of rubber, distinguished by their origin and method of preparation, will have completely disappeared from the market. In spite, however, of the enormous strides that have been made in the preparation of Plantation Rubber, the old-time method, practised on the Amazon valley on Para rubber, still holds its own. It can be spoken of still as the one by which the best rubber on the market is obtained.

In this method the latex is collected in cups from incisions made in the bark of the tree. A pail, or a large gourd bottle, is used to collect the contents of the cups. The whole collection is brought to the hut of the native, where a fire is lit in a fireplace scooped out of the ground. On the lower Amazon the fruit of the Urucuri or of the Naussu palm (*Atalea excelsa* and *Manicaria saxifera*) is added to the faggot fire, which increases the thickness of the smoke.

As soon as sufficient smoke has developed, the cauchero takes the pallette, a wooden instrument with a handle 3 to 6 ft. long, and holds the broad, flat, end of this over the smoke for a moment, then dips it into the pail containing the latex, and then holds it again over the smoke, rotating it at the same time in order to coagulate the adhering latex. This process is repeated until a ball of rubber of the required size has been formed, which is then removed from the paddle, dried for several days and despatched, usually as " fine Para biscuits," to the nearest trading centre. In this condition the rubber remains for some time prior to washing. It is believed that the smoke from the palm nuts possesses valuable antiseptic and other properties, on account of the presence in it of small quantities of creosote and other substances, and there is no room for doubt in our mind that the excellent quality of Para rubber is due more to the method of its preparation than to any exceptional properties of the latex from which it is derived. *By reason of its method of preparation, Para rubber contains all the elements of the latex distributed uniformly throughout its mass.*

Para entrefine, Negro Heads, Sernamby, are but less pure varieties of fine Para, prepared usually from the rubber which adheres to the tree during tapping, and to the vessels containing the latex.

In the method of preparation of Plantation Rubber as practised in Ceylon and the Far East, the latex of the *Hevea brasiliensis* or Para rubber tree is collected in cups which are attached to the tree at points to which a number of excisions cut in the bark all lead. The system of excision or tapping practised on rubber plantations, is fairly uniform as compared with the variety of methods practised on the Amazon. In the Far East that method is favoured which claims to obtain a maximum flow of latex at regular intervals from a given area of the tree's surface with a minimum of injury to the tree. Whether these objects are always attained by the methods practised or not, is a question which is beyond the scope of the present article.

After the latex has been collected and brought to the factory, there is added to it such an amount of a vegetable acid—acetic acid diluted with water is usually employed—as experience has shown to be necessary to bring about the coagulation of the entire latex. By the addition of this acid the finely divided particles of rubber separate and are caused to coalesce to form larger aggregates, which by gentle pressure, or on mere standing, unite to form a solid mass of elastic rubber. Recently it has become the custom on rubber estates to add to the latex before coagulation a small amount of sodium sulphite. This is now in common use, and by means of it the darkening in color which would otherwise occur in the raw rubber is almost entirely prevented. This must be regarded as a great step in advance in the preparation of Plantation rubber; not, however, on account of any increased value given to the product in the eyes of the modern rubber manufacturer, but on account of the advantage to the producer in being able to turn out a clean, inviting-looking product for the market. In the preparation of Plantation rubber it should be noted that a large quantity of liquid (serum) separates from the coagulated mass of rubber. This serum contains small quantities of several substances, both organic and inorganic, which are, therefore, lost as far as the rubber is concerned. Almost immediately after coagulation the rubber is washed mechanically and hung in the drying-room till dry. It is claimed, and with right, that Plantation rubber, when dry, is ready for manufacture, whereas the Amazon Para loses from 17–20% of its weight in the washing and drying rooms of the manufacturer—a not unimportant difference, both technically, in the results produced, and commercially. *Plantation rubber may well be said to suffer from excessive purity.*

In the preparation of Plantation rubber the amount of acid used in coagulation has a very profound influence on the quality of the resulting rubber ; this amount should be as small as possible. In view, however, of the entire absence of anything like scientific accuracy in determining the amount of acid required, it is not to be wondered at if Plantation rubber is to be found on the market to-day showing variations of over 60% in quality, but variations in Plantation rubber only become apparent in manufacture, and are being entirely overcome by the modern methods of science. It is amusing, however, to read the so-called rubber expert still continues to lay the blame for these variations upon the poor youthful but harmless rubber-tree, which carries out its functions with a precision that bids fair to shame even its exploiter.

In a few more years by far the greater part of the world's supply of raw rubber will be derived from Plantation sources. For this reason we do not feel that it is necessary again to discuss in detail methods which may still be in vogue for the preparation of raw rubber, but which are fast disappearing or have already lost all commercial importance. A full account of such methods was given in the introductory chapter of our Lectures on India Rubber (1909) and we must refer those of our readers who are interested in this question to those pages.

Let us turn now to the raw rubber itself. This is usually light in colour when first prepared, but it rapidly darkens when left exposed to the air, and becomes finally almost black in the case of most rubbers. This change in colour is due in great part to the presence of substances known as enzymes, associated with the protein in the rubber, and can be prevented, as has been pointed out, if suitable precautions are taken at the time of coagulation to remove or destroy the active enzyme or the substance on which this acts.

India-rubber is insoluble in water, but its weight increases by its absorption of this solvent, of which it may take up as much as 45–50%. It is insoluble in alcohol or acetone, the two most common solvents for the extraction of the resinous products contained in it. It dissolves in such substances as chloroform, toluol, benzol, ether, etc., with greater or less rapidity, yielding viscous, homogeneous solutions. Raw rubber is very elastic at ordinary temperatures, but if the temperature is reduced to below zero it becomes hard and brittle, although it regains its former properties on warming. If heated to 75° C., or over it becomes gradually soft and sticky, and does not regain its normal properties on being cooled. If exposed to higher temperatures it melts and breaks down finally, into simpler derivatives. If exposed for a long time to air and sunlight most rubbers gradually become sticky, and in presence of oxygen are oxidised completely into resinous products soluble in acetone. Hence it is that, for practical purposes, almost all the rubber of commerce undergoes vulcanisation. By vulcanisation, which is the chemical union of rubber with sulphur or sulphur chloride, a product is obtained which is more elastic than ordinary raw rubber, and, at the same time, is less affected by atmospheric and temperature changes of any kind.

It must not be supposed, however, that commercial india-rubber is chemically pure caoutchouc. Even the best products are far from pure, and the poorer varieties contain, in addition to the ordinary impurities, varying quantities of moisture, soluble impurities from the latex, and extraneous impurities such as sand, bark, etc., which have found their way accidentally into the latex, or have been intentionally added to it. Such rubber can, however, be further purified by mechanical washing (which removes the soluble and mechanical impurities), followed by drying. This is, indeed, the first process which rubber goes through before manufacture, and the product thus handled is known as technically pure or washed rubber. The " loss on washing " is a valuable consideration from the manufacturer's standpoint, and is usually determined in practice. As the tables at the end of this article show, this " loss on washing " is a very variable factor, except in the case of Plantation rubbers, which show practically none.

The " technically pure " or washed dry rubber still contains certain substances other than caoutchouc. No amount of mechanical washing will remove these substances which are known as the resins and proteins of the rubber. They form the impurities always present in all rubber, and their determination is a matter of considerable importance. One rubber may contain only 1–2% of resin, whereas others contain more than 60% of products which are soluble in acetone and which are classed, therefore, as resins. On the other hand, whereas Para rubber seldom contains more than 4% of protein, the rubber from Manihot or Castilloa latex may contain as much as 10%. Too little importance has been attached to these two impurities, which account for many of the observed phenomena in raw rubber and in the treatment of rubber in manufacture.

In the vulcanisation and manufacture of articles of india-rubber two distinct processes are in use. In the first, a small quantity of sulphur, or a substance liberating sulphur on the application of heat, etc., is incorporated with the rubber, and the vulcanisation is effected by heat. In the second, the rubber is treated in the cold with the vapour of sulphur chloride or with a dilute solution of sulphur chloride in benzol, or other suitable solvent. This method is only applicable to the vulcanisation of articles of rubber which are thin enough to admit of uniform vulcanisation throughout the mass. Its use is confined, therefore, to the manufacture of such articles as surgeons' gloves and rubbered fabric, and to the vulcanisation of cements when the use of sulphur is not possible.

By far the largest part of our manufactured products are vulcanised by means of sulphur. In this process the washed and dry rubber is first placed between the two rolls of a powerful mixing mill where it is " broken down " by a process of kneading into a soft, doughy mass. This process is accelerated by the difference in speed of the two rolls of the mill and by heating the rolls internally by means of steam.

As soon as the rubber has been reduced to a plastic mass of the proper consistency, the sulphur and other ingredients required to effect vulcanisation and to give to the finished products the required physical and other properties, are added, and the mixing is continued until all the various ingredients are taken up by the rubber and have become uniformly distributed throughout it. Usually about 5–10% of sulphur on the weight of the rubber is added to each batch ; actually 2,2–2,8% is sufficient and can be used to give a good technical vulcanisation if certain other necessary conditions in the vulcanisation process are fulfilled. The product thus obtained is placed in moulds of the required shape and size, or it is run out into sheets on a calendar and formed in this way into the articles required, and then vulcanised. Vulcanisation may be effected by steam under pressure, when the article is placed in a large digestor into which "live" steam is injected, or by heat alone, or by heat and pressure combined where the material is placed in a mould between the plates of a powerful hydraulic press, heated by steam. Each of these methods of vulcanisation has its own field of usefulness and application.

From what has been said it is not to be supposed that manufactured rubber consists of rubber and sulphur only. This is only true of a very few articles (such as rubber thread). The vast majority of rubber goods nowadays are loaded with mineral and other substances, and contain less than 35% of rubber by weight. Other ingredients, inorganic and organic, are added with the sulphur to the rubber on the mill, some of these serving a very useful purpose, others, like the inert minerals, being added merely as fillers. It is impossible to enter here into an account of the various ingredients used in the manufacture of india-rubber, and their function therein. On the use of these various ingredients in the proper proportions efficiency in manufacture depends, and it is not surprising, therefore, if the modern manufacturer still guards with considerable care these, the secrets of his business. In addition to the inorganic and organic ingredients which are purchased and added to the rubber, all the various waste products of the manufacture are worked back in one form or another into manufactured goods. In this way a very large field of usefulness has been found for the reclaimed waste rubbers.

It would take one too far afield to describe the methods by means of which the properties of the various articles of india-rubber are produced in practice. Hard rubber or ebonite is obtained by mixing with the rubber a much larger percentage of sulphur than is required in the manufacture of soft rubber goods, and the time required for vulcanisation is usually longer. In the manufacture of soft-cured rubber goods the time of vulcanisation may vary from 5 minutes to 3 hours at 40 lbs. steam pressure, whereas in the manufacture of hard rubber it is difficult to effect complete vulcanisation in less than 90 minutes by 40 lbs. steam pressure without a large excess of sulphur.

In regard to the nature of the rubber substance itself, it must suffice to say that it is a complex hydrocarbon (*i.e.*, a body containing the elements carbon and hydrogen in a definite proportion) belonging to a class of bodies known in organic chemistry as the cyclo-octadiens. To the extreme complexity of the caoutchouc molecule its unique physical properties are due. For the past three years organic chemists, in all parts of the world, have been trying to build up this substance from such well-known products as turpentine oil, petroleum oil, coal tar oils, starch, alcohol, calcium carbide, etc., in the belief that it is possible by some means to bring about a synthesis of rubber as economic as that effected by the plant. Great strides have already been made in the solution of the problems underlying, and one cannot but hope that untiring efforts will be rewarded by ultimate success. Synthetic rubbers have already been prepared, but the true economic value of the products still remains to be determined. In spite of the volumes of patent and other literature which have appeared upon the subject of the synthesis and polymerisation of isoprene and allied hydrocarbons to rubber-like substances, experimentation still reveals the fact that the subject is, as yet, only in its infancy, and that much still remains to be done before commercial synthetic rubber is even theoretically possible.

In conclusion, a table has been drawn up comprising all the known brands of india-rubber, showing their botanical as well as their geographical origin, their loss on washing and their resin extract. These tables are similar to those which appeared in our previous issues, but it has been found necessary to rearrange and correct the entire data which we presented at that time. In our new arrangement the first place has been given to the Eastern Plantation Rubber, on account of its increasing importance. Before long this rubber will undoubtedly rank as the chief source of the world's supply. The analytical and technical constants given in the tables represent the highest and lowest values obtained from a long series of estimations. It is hoped, therefore, that they will be of value to all.

(*a*) Plantation Rubber—Cultivated Rubber.

TRADE NAME.	Geographical Origin.	Chief Export Centre.	Botanical Origin.	Loss on Washing. (per cent.)	Resin in Washed Dry Rubber. (per cent.)
Plantation Rubber.	Ceylon.	Colombo.	*Hevea brasiliensis.* Muell. Arg., almost entirely. The cultivation of Manihot and Castilloa almost extinct.		
Plantation Para Rubber.	Straits Settlements	Singapore		*Crêpe* 0.2—1.0	
	Fed. M. States.	Penang.			
" *First Latex* " as *Crêpe*, thin pale, light, dark, brown, mottled, thick, blanket, etc., etc. *Sheet* as by crêpe; also smoked and unsmoked.	Sumatra.	Penang, Belawan Padang.		Biscuits, Sheets & Block 1—2 *Scrap* 8—12	1.3—3.6
	S. India.	Tuticorin, Colombo			*Scrap* 2.5—4.5
	Burma.	Rangoon.			
Biscuits and *Block*. *Scrap* as Tree Scrap, Field Scrap, Bucket Clot, Cup Bottoms and washings (generally sold as " Scrap Crêpe or Sheet," but sometimes as " First Latex smoked crêpe or sheet ") ; also Bark Scrap and Earth Scrap as " Bark Crêpe."	Borneo; with Sarawak, Brunei, B. N. Borneo and Dutch Borneo.	Singapore, Bandjérmassin, Kuching Labuan.			
	Java.	Batavia.	*Hevea brasiliensis.* *Ficus elastica*, Roxb.		Cultiv., *Ficus elastica* 3.5—12
	French Indo-China	Haiphong, Saigon, Hanoi, Tonkin	*Hevea brasiliensis*		
	Siam.	Bangkok.	*Hevea brasiliensis.*		Ceara 1.4—8.5
	Philippine Islands.	Zamboanga.	*Hevea brasiliensis* ; also *Manihot Glaziovii* and *Castilloa elastica* (exptl.).		Castilloa 2.5—20
	New Guinea and The Celebes.	Batavia and Singapore.	*Hevea brasiliensis.*		

EASTERN RUBBER BRANDS—(*continued*).

(*b*) Indigenous Rubbers.*

TRADE NAME.	Geographical Origin.	Chief Export Centre.	Botanical Origin.	Loss on Washing. (per cent.)	Resin in Washed Dry Rubber. (per cent.)
Assam.	Assam.	Calcutta.	*Ficus elastica*, Roxb., chiefly.	13—29	3.7—10
Rangoon.	Burma and Annam.	Rangoon.	*Ficus elastica* and species of Urceola.	12—30	4—10
Penang.		Singapore.	Species of Ficus, Willughbeia, and Urceola.	27—31	7—9
Rambong Rubber.	Straits Settlements and F.M.S.	Penang, Singapore.	*Ficus elastica*, Roxb.		3.7—8.5
Sumatra.	Sumatra.	Belawan, Penang, Padang.	*Ficus elastica*, Roxb. *Willughbeia firma*, Urceola, Hymenolophus, Parameria, Chonemorpha, Ecdysanthera.	10—25	7—15
Palembang.		Palembang.	*Dyera costulata*, Hook.	64—70	70—85
Borneo. Bresk, Pontianac, Jelutong, Bandjérmassin.	Borneo.	Singapore, Bandjérmassin. Labuan, Kuching.	*Willughbeia firma*, Spec. Urceola, Parameria. *Dyera costulata, Hook.*	35—50 64—70	70—85
Java.	Java.	Batavia.	*Ficus elastica*, Roxb.	10—30	3.7—8.5
	French Indo-China.	Haiphong, Saigon, Hanoi Tonkin.	*Parameira glandulifera* Benth; *Ecdysanthera micrantha* D.C.; *Xylinabaria Reynaudi* Jum.; *Bleekrodea Tonkinensis*.	15—30	6—8

* Exploitation rapidly declining.

2.—SOUTH AND CENTRAL AMERICAN BRANDS.

TRADE NAME.	Geographical Origin.	Chief Export Centres.	Botanical Origin.	Loss on Washing. (per cent.)	Resin in Washed Dry Rubber. (per cent).
1.—Para, fine Islands, soft cure.	Brazil, the islands of the lower Amazon and its delta; also other parts of the State of Para.	Para.	*Hevea brasiliensis*, Muell.Arg. *Hevea Sp.* "*Itauba*" Ule. *Hevea Spruceana*, Muell. Arg. *Sapium Tabura*, Ule n. sp.	17—20	2—3
2.—Para entrefine, Islands entrefine.				18—25	2—3.5
3.—Negroheads, or Islands coarse, Sernamby.				20—40	2—6
4.—Fine Para, Upriver, hard cure.	The district lying on both sides of the Amazon and some distance up. Also the district drained by its large tributaries, the Jura Madeira, Rio Negro, etc., etc.	Manaos, Para, Iquitos Serpa.	*Hevea brasiliensis*, Muell. Arg. *Hevea* "*Itauba*" Ule. *Hevea discolor*, Muell. Arg. *Hevea Sp.* from Rio Negro. *Hevea Similis*, Hemsl. *Hevea biglandulosum*, Ule *Micrandra siphonioides*. Benth.	14—19	1.6—3.0
5.—Upriver entrefine, hard entrefine, Upriver medium.				16—25	1.9—3.2
6.—Upriver coarse or Manaos Scrappy Negroheads.				18—23	1.5—3.2
7.—Cameta Negroheads.	South-western Para.	River Harbour. Cameta.	*Hevea brasiliensis*, Muell.Arg. *Hevea spruceana*, Muell. Arg. *Sapium Tabura*, Ule n. sp.	37—57	1.2—2.2

2.—SOUTH AND CENTRAL AMERICAN BRANDS—(*continued*).

Trade Name.	Geographical Origin.	Chief Export Centres.	Botanical Origin.	Loss on Washing. (per cent.)	Resin in Washed Dry Rubber. (per cent.)
8.—Upper Caucho Balls.	Amazon district and its southern tributaries ; also yielding Para Rubber.	Manaos, Para Iquitos, Serpa.	*Hevea brasiliensis* and other Hevea species.	18—23	3.5—5.5
9.—Lower Caucho Balls (also Peruvian.			Various species of Sapium for Caucho blanco and *Castilla Ulei*. Warb. for Caucho-negro.	26—30	4—5.5
10.—Caucho Slabs and Strips (also Peruvian).				35—42	4—8
Ceara Scrap, Ceara Coarse, Negroheads Coarse. Maniçoba, Maniçoba Coarse Scrap, etc.	Province Ceara, Piauhy and Rio Grande do Norte.	Ceara, Paranahyba.	*Manihot Glaziovii*, Muell. Arg. *Man. Piauhyensis*, Ule. *Man. Heplaphylla*, Ule. *Man. Dichotoma*, Ule. *Man. Violacea*, Muell. Arg.	25—46 30—55	2.5—4 3—6.5
1.—Matto-Grosso, Fine and Entrefine.	Province of Matto-Grosso, Brazil.	Monte Video, Rio Janeiro.	Spec. Hevea, probably *brasiliensis* and others.	23—29	2.5—3.5
2.—Matto-Grosso, Virgin Sheets, White Para.				15—30	2.5—3.5
3—Matto-Grosso, Negroheads.				25—35	2.5—6
Matto-Grosso Sheets, Mangabeira or Pernambuco Rubber, Bahia-Mangabeira, Bahia Sheets.	The Provinces Pernambuco, Bahia, Goyaz, Sao Paulo, Maranhao, etc.	Santos, Rio Janeiro, Bahia, Pernambuco, Sergipe.	*Hancornia speciosa*, Muell. Arg.	44—55	6—12

2.—SOUTH AND CENTRAL AMERICAN BRANDS—(*continued*).

TRADE NAME.	Geographical Origin.	Chief Export Centres.	Botanical Origin.	Loss on Washing. (per cent.)	Resin in Washed Dry. Rubber. (per cent.)
Bolivian, fine, medium. Virgin, coarse, entrefine Uncut Bolivian.	Bolivia.	Manaos, Mollendo, Arica, and various Peruvian and La Plata ports.	Various species of Hevea.	17—18.5 15—22	1,6—3.1
Mollendo, fine, medium and coarse.	South Bolivia and small lots from Peru.	Mollendo.		15—25	1.9—3
1.—Peruvian, fine, medium and scrappy. Peruvian Balls (also Caucho).	Peru.	Iquitos, Manaos, Mollendo.	*Hevea brasiliensis*, Muell Arg. *Hevea* "*Itauba.*"	20—30	3.3—5
2.—Peruvian Tails (also Caucho).		Iquitos.	*Castilla Ulei.*, Warb.	20—35	3.6—4
Orinoco Coarse Para; also Angostura Para or Ciudad, Bolivar Rubbers.	Venezuela.	Ciudad, Bolivar.	*Hevea Knuthiana*, Hub.	22—24	2—3
Ecuador Scrap, Sausage. Esmeralda Sausage. Caucho blanco. Caucho Negro.	Ecuador.	Guayaquil, Esmeraldas.	*Sapium verum*, Hemsl. *Sap. utile*, Preuss. *Sap. decipiens*, Preuss. *Castilla elastica*, Cerv.	23—35 (Esmeralda Saus. 16—28)	3—8.5
Columbia Virgen or Scraps (Caucho virgen). Carthagena.	Columbia.	arranquilla, Tumaco, Cartagena, Sabanilla.	*Sapium tolimense*, Hort.	20—30	3—8.5

2.—SOUTH AND CENTRAL AMERICAN BRANDS.—(*continued*).

TRADE NAME.	Geographical Origin.	Chief Export Centre.	Botanical Origin.	Loss on Washing. (per cent.)	Resin in Washed Dry Rubber. (per cent.)
West Indian, or Central Scrap, Slabs, Sheets, Strips and Sausage.	Costa Rica.	Port Limon, Puntas, Arenas, Greytown.	*Castilla elastica*, Cerv.	22—35	3—8
Nicaragua Scraps, Sheets and Sausage.	Nicaragua.	Bluefields, Corinto, San Juan del Sur, Greytown.		21—35	3—8
West Indian or Centrals, also Guatemala Sheets and Slabs.	Honduras, Salvador. Guatemala.	Puerto Cortex Belize; St. Salvador; St. José, Livingston.		20—35 40—53	3—8 —
Mexican Strips or Scrap.	Mexico.	Vera Cruz, Puerto Mexico.		21—31	3—8
Guayule, as Parra, Saltillo, Madero, Circle Brand, Torreon, Star Brand, Merced, Parkers Best, etc., etc.*		Tampico.	*Parthenium Argentatum*, A. Gray.	15—40 (According to Brand.)	—
West Indies Rubber, Trinidad. (Cultiv. and Exptl. almost entirely).	West Indies. Antilles. Trinidad.	———	*Forsteronia floribunda*, D.C. *Cryptostegia grandiflora*, Br. (Cultiv.: *Castilla elastica* and *Hevea brasiliensis*.)	—	—

* Most of these Brands now extinct.

3.—AFRICAN BRANDS.*

TRADE NAME.	Geographical Origin.	Chief Export Centres.	Botanical Origin.	Loss on Washing. (per cent.)	Resin in Washed Dry Rubber. (per cent.)
Soudan Niggers, Twists, Cakes, Balls.	French Senegal.	St. Louis. Dakar.	*Landolphia Heudelotii*, D.C.	15—50	6—7 (approx.)
Gambia Niggers or Casamance.	British Gambia.	Casamance. Bathurst.		15—45	6—7 (approx.)
1.—Gambia Balls. 2.—Bissao Balls or Niggers. 3.—Bissao Flats.	Portuguese Guinea and the Bissao Islands.	Bissao. Bulam. Caches.		15—45	6—7
Massai Niggers. Konakry Niggers. Adeli Niggers.	French Guinea.	Konakry.		15—44	5—8
Sierra Leone Niggers.	Sierra Leone.	Freetown. Konakry.	*Land. owar.*, Pal. Beauv.	10—40	6—7
Sierra Leone Twists. Manoh Twists.		Sierra Leone.	*Land. Heudelotii*, D.C.	20—30	6—7
Liberia Balls. Liberia Lumps.	Liberia.	Monrovia.	*Land. owar.*, Pal. Beauv.	15—35	6—7

* Many Brands mentioned here fast disappearing or already extinct.

3.—AFRICAN BRANDS—(*continued*).

TRADE NAME.	Geographical Origin.	Chief Export Centre.	Botanical Origin.	Loss on Washing. (per cent.)	Resin in Washed Dry Rubber. (per cent.)
Grand Bassam, Grand Bassam Niggers, Bassam Lumps, Assinee Twists.	Ivory Coast.	Bassam, Assinee, Accra, Lahou.	*Land. owar.*, Pal. Beauv. *Ficus Vogelii*, Miq. *Funtumia elastica*, Stapf. *Clitandra elastica.* *Clit. eugenifolia.* *Clit. laurifolia* and *Carpodinus Hirsutus* for Accra Paste.	25—35	6—8
Gold Coast and Ivory Coast Lumps, Gold Coast and Ivory Coast Cakes, Ivory Coast Niggers.	Gold Coast.	Asim, Cape Coast Castle.		30—55	7—10
Lahou Twists, Lahou Niggers, Lahou Cakes.				—	—
Accra Lumps, Accra Paste.				36—60	7—10
Adda, Quitta, Lome Niggers.	Togo.	Ports as named	*Land. owar.*, Pal. Beauv. *Ficus Vogelii*, Miq.	30	—
Lagos Lumps, Biscuits, Strips. Lagos Silk Rubber.	Lagos.	Lagos.	*Land. owar.*, Pal. Beauv. *Ficus Vogelii*, Miq.	40—60 —	10—30 9—12
Niger Niggers.	Southern Nigeria.	Old Calabar.	*Funtumia elastica*, Stapf. (Lagos silk rubber from *Funtumia elastica*)	35	—
Benin Lumps, Old Calabar Lumps.				25—30	—
Cameroon Balls, Biscuits, Twists, Bata Balls, Batanga Balls. South Cameroon Rubber.	Cameroon.	Victoria, Kribi, Duala.	*Funtumia elastica*, Stapf. *Land. owar.*, Pal. Beauv. *Land. Klainei*, Pierre. *Carp. Landolphioides*, Stapf.	26—45 28	10—20 10.5–12.5
Gabun Balls, Loango Balls, Mayumba Balls, Congo Balls.	French Congo.	Libreville. Brazzaville.		26—35	—

TRADE NAME.	Geographical Origin.	Chief Export Centre.	Botanical Origin.	Loss on Washing. (per cent.)	Resin in Washed Dry Rubber. (per cent.)
1.—Upper Congo, black.	Independent Congo State.	Leopoldville, Boma, Banana.	*Land. owar.*, Pal. Beauv. *Land. Klainii*, Pierre. *Land. Gentilii*, de Wild. *Land. Droogmansiana*, de Wild. *Clitandra Arnoldiana*, de Wild. *Clitandra Nzunde*, de Wild. *Funtumia elastica*, Stapf. *Land. Thollonii*, Den.	2—10	3—5
2.—Upper Congo Balls, Upper Congo Jakoma spindles, Ikelemba, Congo Djuma, Upper Congo Yengu.				—	—
3.—Black Kassai, fine.				7—10	—
4.—Red Kassai, fine, niggers.				6—11	—
5.—Kassai Loanda Sankuru. Kassai Loanda Nuts.				19—21	—
6.—Upper Congo Equateur, I.				6—7	3.3—3.8
7.—Upper Congo Katanga, Aruwimi, Aruwimi (from Equateur Ia), Lac Leopold.				6—35	3
8.—Uellé Strips.				6	5.0
9.—Upper Congo Ordinary (Balls and Cherries.)				20—30	5—8
10.—Red Congo Thimbles.				12—35	8—10
Red Angola Thimbles, Niggers.	Angola.	Benguela. St. Paolo de Loanda. Mossamedes. Ambriz. Novo Redondo.	*Land. owar.* *Land. Thollonii.* *Carpodinus chylorrhiza.* K. Sch. *C. gracilis.*	18—30	—
Loanda Niggers, Thimbles.				8—20	4—7
Benguela Niggers.				20—27	4—6

3.—AFRICAN BRANDS—(*continued*).

TRADE NAME.	Geographical Origin.	Chief Export Centre.	Botanical Origin.	Loss on Washing. (per cent.)	Resin in Washed Dry Rubber. (per cent.)
Lourenço Marquez, Inhambane; Beira, Ibo, Mozambique (balls, spindles, marbles).	Portuguese East Africa.	Ports as trade names.	*Land. Kirkii*, Dyer, and var. *Delagoensis*, Pierre.	30—50	6—8
Nyassa, Lindi balls, Donde marbles, Lamu balls, Mombassa, Tanga, "Mgoa" rubber. (Cultivated Manihot experimentally mostly.)	German East Africa.	Chinde, Kilwa Lindi, Zanzibar, Tanga, Lamu.	*Land. Kirkii*, Dyer. *Land. dondeensis*, Busse. *Clitandra kilimandjarica*, Warb. *Mascarenhasia elast.* K. Sch. *Land. Kirkii* Dyer.	30—50	6—10
Plantation Funtumia.	BritishEastAfrica and Uganda.		*Funtumia elastica*. Stapf (for Plantation Rubber).	3—5	9—12
Clean brown spun Balls, White Virgin Sheets, White Slab, Pinky Madagascar.	Madagascar.	Tamatave, Majunga, Nossi-Bé, Fort Dauphin, Marandawa, Maintirano, Manandjary.	*Land. madagascariensis*, K.Sch. *L. Perrieri*, Jum. *L. Sphaerocarpa*, Jum. *L. tenuis*, Jum. *Mascarenhasia lisianthiflora*, D.C. *M. anceps*, Boiv. *M. longifolia*, Jum. *M. utilis*, Bak. *M. Geayi*. *M. kidroa*. *Marsdenia verrucosa*, Den. *Cryptostegia madagascariensis*, Boj. *Plectaneia elastica*, Jum. *Euphorbia Intisy*, Dr.d.Cast.	19—29	5—7
Mixed Majunga, Black coated Slab.				26—35	6—10
Madagascar Niggers (East and West Coast Niggers.)				25—45	6—10

Part I.

CHAPTER II.

The Systematic Study of Rubber Production.

By

R. N. LYNE, F.L.S., F.R.G.S.

(Director of Agriculture, Ceylon).

When Sir Robert Chalmers, our present Governor, first came to Ceylon, he said in answer to an address from the Planters' Association, that the planting industry of Ceylon was without parallel in the world. Many who are here, if not from Ceylon, are indirectly connected with it, and if I venture to address you, whose achievements have been so strikingly described, it is only in the capacity of a student. But I speak as a student to students, because, though you have built up the great rubber industry of the East, yet in this age of progress efficiency can only be achieved by keeping our minds always open to study new ideas that arise and to abandon old beliefs that have been proved fallacious. The only qualifying condition I should insist upon is that there shall be reasonable grounds for believing that new ideas would be likely to lead to useful results, and that established practice should not be abandoned till it had been proved wrong. I don't think there is any need for me to labour the latter point with the practical business people who are here to-day.

I plead, then, for study. Let no planter think that his system of planting, or of cultivation, manuring, tapping or preparation is the best that can be applied, even though he may be getting more rubber per acre than anyone else, or a better price. It may be, even in the case of the most successful, that he is applying among his mixtures manures that have little or no effect upon the yield of latex, or that his methods in the factory are capable of many improvements in detail.

But study should be systematic. We should not only have a clear idea of the goal we wish to reach, but also of the road we intend to follow step by step to try and get there. During the two years I have been in Ceylon I have been much impressed by the enormous amount of investigation that has been carried out, not only in the case of rubber, but of other products also, and though valuable results have been reached, yet they are not always available, because the experiments belong to no systematic scheme of investigation, but have been carried out by individuals pursuing the study of the ideas they had formed.

The Treatment of the Soil.

In our treatment of the soil we are, I think, to a great extent groping in the dark, particularly in respect of manuring, because of our ignorance of the manurial requirements of the Hevea tree. If we apply a manure to Hevea of which it cannot take full advantage we are not getting full value for our money, any more than a farmer would be who top-dressed his turnip crop with nitrate of soda. I have seen many experiments suggested and described, but on examination it was often impossible to determine the object with which they had been devised, further than to find out whether the result from one particular treatment were better than that from another.

Principles and not particular treatments are what we want to get down to, and to do that we should model our research work in the field on that of Lawes & Gilbert, who repeated their experiments year after year till all possible subsidiary influences had been eliminated, and cause and effect stood clearly revealed.

The general scope and plan of the field experiments at Rothamstead has been "to grow some of the most important crops of rotation each separately, year after year, for many years in succession, on the same land, without manure, with farmyard manure, and with a great variety of chemical manures; the same description of manure being, as a rule, applied year after year on the same plot." In the case of wheat that plan has been followed out for 70 years, namely, since 1844. We require to establish our field experiment work upon a correspondingly systematic basis, in order to acquire definite and indisputable evidence upon such points as the effect of nitrogen, potash and phosphoric acid upon the flow of latex, the percentage of rubber, and bark renewal; whether nitrogen is better applied in organic or mineral manures; the degree of solubility in which phosphates should be administered; the best combination for potash, the extent to which soil analysis can help; the value of tilth and green manuring. The application of artificial manures to rubber plantations is extensively and successfully practised, but no root principles upon which to proceed are as yet available for the planting public as they are for the farmer. In the tropics we are dealing with conditions different from those that exist in temperate latitudes. We have a greater rainfall, generally speaking; a more powerful sun, compelling a more vigorous circulation in the tree; plants that occupy the land for four generations of men instead of for four months, with roots that search the soil to undetermined depths. In the tropics we have at our command natural forces that work with tremendous energy as compared with those of colder climates, and we should take the utmost advantage of those forces. On the other hand, we can reduce the scope as far as chemical mixtures go, because Lawes & Gilbert, being almost completely in the dark as to the effect of chemical ingredients upon crops, experimented with such compounds as for example sulphate of soda, and cleared a lot of ground over which it is not again necessary to travel.

The study of these questions, according to a system devised so as to leave no possible grounds for uncertainty at any point, would lead us to a knowledge of the principles on which we must proceed to influence the tree through the soil.

Light and Air.

But the Hevea, like other trees, lives largely upon the atmosphere, deriving only a fraction of the dry matter from which its tissue is built up, from the soil; by far the largest proportion it absorbs through its leaves from the air. It must be manifest that in the atmosphere we have also a potent instrument for influencing the tree. This, of course, affects the question of spacing and thinning out, a very involved question. If we took full advantage of utilising the stores of food that exist in the air, the treatment of the soil with Hevea would not, I think, occupy our attention quite so exclusively as it does at present, and we should probably be spared considerable annual expenditure.

Experiments at Heneratgoda have brought out in a striking way the value of light and air. It is sometimes objected that, being much older than most plantation trees, the Heneratgoda trees are useless for experiment purposes, but this argument has no bearing upon the present point, because these old trees, when cramped up as many of them are, are poor yielders. It is only those with an ample supply of light and air that give the large yields.

I sometimes think that the cult of manuring tends to obscure the first fundamentals of good farming as expounded by Jethro Tull, who prepared the way for Lawes & Gilbert by opening out his plants and giving them room. No amount of manure would give you a good crop of turnips unless you thinned them out and gave each plant room fully to develop above ground. We may lay it down without, I think, fear of refutation, that to give the best results a Hevea tree must have room fully to develop its dome. Accepting this, we have next to reconcile the fact with the importance of producing early dividends, and come to a compromise that will best serve the interests of the plantation throughout its career.

THE STANDARDISATION OF RUBBER.

I pass over, for want of time, the question of tapping, of the period for resting the trees, of the movements of plant food in the trees, the formation of nodules. It would appear that we may be approaching some agreement as to the best methods of tapping, though I think that cannot be finally settled till we know more about the source of latex and the effects of tapping upon the stores of food in the tree from which the latex is derived. If we rest trees it is generally when they " winter." but it is possible that we should do better if we modified this practice to some extent. I pass over these questions, all of them demanding patient organised investigation, and come to the standardisation of rubber, a subject upon which our minds are perhaps more immediately engaged during this exhibition.

What do we mean by the standardisation of rubber ? I should define it as the preparation of rubber in the factories of plantations according to a system, or systems, that shall ensure each commercial grade being of standard or uniform quality. The New Zealand sheep breeder who caters for the frozen mutton market must breed his wethers to a certain weight ; if they are above or below that weight, a fixed margin being allowed, they are rejected. The Colonial dairy factories must turn out their butter and cheese of uniform standard quality. Indeed, we all understand the principles involved, but what we have not yet fully realised is the importance of the rubber industry falling into line with these great commercial principles.

The whole ground of plantation factory practice must be covered. Taking into account the different treatment rubber is exposed to in coagulating, milling, smoking, drying, rubber is now being prepared in a great variety of ways in the factories of the East. Furthermore, there are probably few factories where the preparation is identical from day to day ; some slight difference occurring perhaps in the strength of the coagulant, or in the number of times the crepe is passed through the rollers. Before we talk of being able to standardise rubber, we require to know which of all these numerous methods give us the best results after vulcanisation. The preparation of the samples from bulked latex drawn from selected trees must be done by a specialist on the plantation, but I think the vulcanizing and testing can be performed better under trained supervision at home, where reference can also be made to the latest manufacturing practice.

The ideal conditions for the standardisation of plantation rubber are large estates or groups of estates with central factories, but there are circumstances well known of course to planters, but upon which I need not now touch, that sometimes operate against the establishment of central factories. Where the opportunity is given us of choosing between a large central factory and a number of small ones, I should unhesitatingly elect the former. In this matter, as also in that of the evolution of the type factory, we can, I think, derive useful lessons from the practice of sugar planters, with whom large central factories are as an article of faith, enabling them to employ one class of men who have specialised as field managers and overseers, and another as factory managers. To place the rubber planting industry on a thoroughly satisfactory basis it will probably be necessary to produce a class of factory managers, but this could only be done where large factories prevailed.

In the sugar factory the cane goes in at one end and the crystals come out at the other, and during the process the juice is never handled. Rubber factories could be arranged so that the different processes would follow one another in orderly sequence. the rubber never being allowed to touch the floor or a wooden bench; and they should be kept as clean as a dairy factory.

CEYLON RUBBER RESEARCH.

In the foregoing I have traversed much of the ground in the production of rubber awaiting systematic research. A large amount of work is now being done, principally in connection with preparation by investigators in the Federated Malay States and Ceylon. They confirm and check one another, and new fields of study are continually being opened. Yet, as it was thought that something more than this was required, the Department of Agriculture of Ceylon, a group of planters represented by the Rubber Research Committee, and the Imperial Institute of London have undertaken a scheme of rubber research, with the object of determining which of the various methods of preparation now in vogue produces rubber of the best quality after vulcanization. Vulcanizing and testing is done at the Imperial Institute with plant provided by the Ceylon Government under the supervision of a trained specialist. The samples will subsequently be submitted to manufacturers. The rubber research chemist, Mr. Campbell, to whom has been entrusted the task of preparing the samples in Ceylon, is also investigating the effect of tapping upon the reserves of starch in the tree. Tapping and manuring experiments are being carried out at Peradeniya and Heneratgoda by the Department of Agriculture, with the advice and assistance of the Committee of Agricultural Experiments.

Systematic research is therefore in progress in Ceylon, which is very satisfactory as far as it goes. But it does not go far enough. I should like to see the work, or some modification of it, duplicated, and a general agreement come to among the Governments in the East and groups employing investigators, to proceed upon definite lines of research and exchange reports. Much of the work being done by the chemists of the

East, important and valuable though it be, is not research work proper, and this paper is not intended to touch upon it. I allude here solely to research work.

What are the essential conditions for successful rubber research work? In the first place it must command confidence; I am referring at the moment to methods rather than to results. Results, very naturally, cannot be finally accepted till they have been repeatedly confirmed and closely examined. But methods should never be exposed to criticism. We have all probably observed a tendency on the part of investigators whose results differ, to explain those differences by criticising each other's methods. That is to be deplored. I am not suggesting that methods are not justly criticised, but what I do say is that they should be beyond criticism.

Another essential condition in the systematic study of rubber production is continuity. The work must not be dependent upon one man, unless, as in the case of Sir John Lawes, he be a man with means sufficient to endow an institution. An institution alone can secure continuity.

Referring to this question of agricultural research, Fream said: "Discoveries cannot be made in a week or a month, as are made in electricity or chemistry, but like those of Rothamstead they can only be looked for, even after the expenditure of much thought and of unflagging industry and perseverance, as the 'long result of Time.'"

Then the work must command the respect of practical men. The object of rubber research is to clear up, if possible, the difficulties with which practical men are confronted. The confidence of practical men can best be gained through their co-operation. Finally, there must be progress. All research work must of necessity be slow, but there should be no *unnecessary* delay.

The Ceylon Rubber Research now being conducted fulfils, I think, the conditions here outlined, so far as investigation into the preparation of rubber goes. There will, I hope, be no unnecessary delay in bringing out results, and whether or not they will compel acceptance there will I think be found no occasion for questioning the methods employed. The Department of Agriculture of Ceylon and the Imperial Institute of London ensure for us continuity, while the co-operation of planters is a guarantee that the work will proceed along practical lines.

I do not think the time is yet quite ripe for such a step, but I hope in the course of a few years we shall find the Departments of Agriculture of the East, and perhaps of the West, united with representatives of the Planting communities in carrying out a common plan of investigation covering the whole field of rubber production. In anticipation of that time we can each pursue our own system of research with as much co-operation as circumstances permit.

The CHAIRMAN: Mr. Lyne's paper reminds us that in connection with the work of research there is one business which could not exist without constant pioneering operations, and that is mining. No mine can go on a commercial basis unless it possesses reserve funds sufficient to keep up a constant round of pioneering work which may be absolutely unprolific. If it is unprolific in the one direction, then attention must be given to some other form of pioneering in the hope that it will become prolific. We had an instance a very short time ago of a company which had done business for a number of years being compelled to wind up for the sole reason that there was no reserve fund available for pioneering. I cite this fact simply to give force to my remark that investigation produces its best proofs when it becomes a habit, not when it is an incidental thing brought out by special circumstances. It must be a habit with every planter and every manufacturer and every man engaged in business of any kind. There are some things which require the full strength of the factory or the plantation to settle up, but these are in the minority, and there is a multitude of questions which can perfectly well be settled in some corner of the factory or the plantation provided the material is there and provided also that its employment is not merely a matter of occasion, but of absolute habit.

Mr. W. F. de Bois Maclaren: Mr. Lyne has endeavoured to cover a good deal of ground, and I am sure those who listened will say that his is a most interesting paper. It raises many questions for both planters and manufacturers. I think the writer was on the right line in regard to many of the matters he has taken up in connection with light and distance, and the facts about the grouping of trees. Such points have not received the attention that they deserve. I think I was the first to call attention to the necessity for a close study of rubber soils and also to the very important part that bacteria play in the growth of trees. These things all call for very systematic study. Planters are very indebted to the experts in Government departments for the work they have done on their behalf in the past, but there is something I want to say about that. It is true that planters have been somewhat shy in accepting the results shown by the Government experimenters, but the reason is that experiments have been conducted over too short a period, they have been limited to too small a number of trees, and have covered areas too small for practical men to pay much attention to them. I think it is for the Rubber Growers' Association to see that many of these questions are studied on a sufficiently large scale and for an adequate length of time. Manuring is one of the subjects that Mr. Lyne has alluded to. Although he has been in other tropical countries, I believe he has been more in Ceylon than elsewhere. Now, the soil of Ceylon compares very poorly indeed with those of some other tropical countries, and it may be that the manures are more valuable in Ceylon than in those other countries. In the last visit I paid to Ceylon I was impressed with the great strides which have been made, especially in regard to the cultivation of tea, as a result of systematic manuring, and more particularly green manuring. These results establish the Ceylon planters as a very fine hard-working class of men, who do not ease off on their work, as we have experienced elsewhere. With regard to the use of chemical manures, those who work in scientific institutions and try to establish cultures for bacteria find that if they employ too strong a chemical admixture of any sort they kill off bacteria. I take it that in the application of chemicals to the roots of trees the effect is the same. Many people express great disappointment with the results of manuring after a time, but it may be that the best results will come later. It is a curious thing that after you burn soil you will eventually get a wonderfully fertile soil. My own opinion is that what is generally needed is more cultivation of the soil; let air into it, and good beneficial bacteria will live. They will not do so unless you get oxygen into the soil. With regard to the value of light and air, I think I suggested already the planting of trees in clumps of perhaps three together. I am glad to see that system is being experimented with in Ceylon. If you want to see fine specimen trees have them grown so. When I visited the estate of the Sumatra Para Rubber Company the manager said, "I want to show you something." He took me to a portion of the estate where there were four very large *Hevea* trees the enormous roots of which he could trace for 80 feet in the swellings of the ground. These trees had been granted the room they craved, for root development and for plenty of light and air. I was told by the manager of the estate, and also by the directors and by the visiting agent, Mr. Patrick Hadow, who is one of the best known V.A's., that these trees each gave 100 lbs. of dry rubber per annum. That seems to prove that if you give your trees plenty of light and air, and room for their roots, you will get results such as you cannot possibly obtain under any other conditions. On the subject of standardising your rubber: I have always urged that this should be done on the estates and not in London. We have only to consider the many different methods of coagulation which are in use, and, by the way, I think the less we use of acetic acid the better the result is likely to be, and it will be better still if we use none at all. Then again, where smoking is pursued, one man does this and another man does the other. Different kinds of fuel are used, and there is no regulation of the temperature, or of the density of the smoke. There are so many different conditions that we cannot for one moment expect to get any standard. I think the Rubber Growers' Association might well send out a number of first-class men, not young men fresh from college, but the most able they can get, pay them handsomely, and let them stay on the estates and watch things with a view to ultimate standardisation. Suppose it costs £10,000 or £15,000, even that money would be very well spent in all probability. I have not met Mr. Lyne before to-day, but he has done a lot of good work in the past, and I am sure he will do much more in the future for the rubber industry.

Mr. P. J. Burgess: Although there are a number of points in Mr. Lyne's paper that one might take up, I should like to deal particularly with the question of standardisation. In this matter I think there is some misapprehension. We in London have during the past year been talking of standardisation and really meaning another thing. We must define clearly what is meant by standardisation, and not have one meaning in London and another in the East. We in London have been concerned rather with variability, and I think we have largely come to the conclusion that it is not possible at the moment to obtain any such uniformity as would lead to the production of standard qualities; that is to say the real qualities of rubber after it has gone through the factory. We can produce a rubber that is apparently uniform. We see in the Exhibition here sample after sample of crepe or smoked sheet, and with all due deference to the judges I defy anyone to say that one is better than the other. I want to see established an institution which will accurately tell the people who are going to use the rubber what their rubber will be like in the use. We should be able to measure and state the real qualities of the rubbers as they are put up for the manufacturers to buy. I will perhaps be justified in again employing an illustration I have used before. We are in the position of a lot of egg merchants, who put their eggs in classes and tell us that some are from chickens and some from ducks. They tell you the colour of the shell, but not one tells you whether the inside is good or bad; that has to be found out by the cook. Our rubbers are all alike. The manufacturer buys them, but he does not know definitely what quality he is buying, and has to find that out for himself in the processes of manufacture. He takes them as a job lot. If you are going to get real qualities on estates how are you going to do it unless you have some system at this end of determining quality? I do not think the Imperial Institute is a place where this work of determining a standard should be carried on, because it cannot be done there from the sale room point of view. The real quality of the rubber as a source of profit can only be decided by the price, and that can never be so accurately obtained from an institution such as the Imperial Institute, which in the end will have to obtain its criterion of quality by submission to the manufacturer, the man who pays the price. I plead very strongly for the establishment at this end, and promptly, of some means of telling what the real quality of the rubber is, and not the apparent quality.

The CHAIRMAN: Why do you advocate that the institution should be here? Why not nearer the scene of action?

Mr. BURGESS: Because every sample that comes forward must be tested. As the majority of the samples come to London it must be done at this end.

The CHAIRMAN: Why not have them standardised at a central place before they leave?

Mr. BURGESS: Because you would have at once to establish stations for Malaya, Java, Ceylon, and Sumatra, or a central station with subsidiary stations, say, in Singapore, Colombo, or Sourabaya. A station of this sort requires men with special knowledge. I question very much whether that particular kind of knowledge is available in Colombo or Singapore. It certainly is available in London. London is the biggest market at present for all plantation rubber, and it seems to be the most convenient place in which a station of the kind should be established.

Mr. A. BRUCE: At the Imperial Institute they are testing on the same lines as manufacturers. They have a vulcanising plant there, and are doing exactly as in a manufacturer's laboratory.

Mr. CROSBIE ROLES: I should like to ask Mr. Lyne whether he hopes to work along lines which will assist the planters to produce uniform rubber. I ascribe the greatest importance to uniformity, which I would place, as regards its immediate interest, in advance of standardisation.

Dr. LOCK: Mr. Lyne has put forward a plea for system and uniformity in research work, and I think everyone will agree so heartily with him on that point that I hesitate to suggest another side to the question. Might I suggest, however, that although in any given establishment or system for experimental work, the bulk of the work should be on lines rigidly defined, a little corner should be reserved for what Charles Dickens used to call "Fools' experiments." By that I mean to say the trial of anything and everything that comes into one's head, a plan that may have no result at all, but might possibly lead to something totally new. To achieve totally new discoveries I think you must have a little lenience and elasticity, and allow your experimentalists to play about and treat matters from the point of view of a pure scientific curiosity.

Mr. W. T. GIBSON: Some confusion seems to have arisen in the use of the term "standardisation," and I think it rests with the London Standardisation Committee to change its title. If it called itself the Evaluation Committee we would not get so confused. When Mr. Lyne was speaking he was referring to the attainment of uniformity, but Mr. Burgess has been referring more to a system of evaluation. The question is, what acceptation are we going to give to the word "standardisation"? This confusion has arisen numbers of times already, and letters appearing in the Press have frequently shown it. Mr. Lyne has made a remark that I may have misconceived, but it was something to the effect that we should not criticise methods. That, however, is one of the most important points in research, the criticism of methods. Another is the determination of experimental error. But if you are to get good results you have to use good methods, and anyone who reads the research literature in any branch of science ought to realise the importance of one research experimenter criticising the method of another if he thinks there is anything wrong with it. Mr. Maclaren has made a remark about the quality of the research men who should be sent to the East. I think it is a mistake to send out newly-fledged scientists to fill certain posts, and my remarks specially apply to the chemists who are sent out under the Rubber Growers' Association Research Committee. Men should be chosen who have already had some experience in rubber factories. This applies with less force to the mycologists. I speak with a certain amount of detachment, because some of the men who have gone out have come from my own college.

The CHAIRMAN: I do not think there is any confusion between the two terms the last speaker has mentioned, because there is no ground whatever for standardisation except on the evaluation basis. Evaluation is the logical ground on which standard is to be determined. It is universally conceded that the value of rubber is determined not on its looks but on its results. I am sure there need be no confusion.

Mr. LYNE: I thank you all very much for the cordial way in which you have received my paper. Perhaps I should add this personal remark, that it was with some reluctance I undertook to read a paper here, because I think that we of the East when we come to London come to learn a lesson and not to talk. We want to know what the manufacturers, the dealers, the brokers and chemists and others who are interested in the rubber industry here really require from us. We want your ideas, for out in Ceylon and the East generally we have some difficulty in finding out exactly what it is you do want. Mr. Maclaren referred to one or two interesting points, especially the value of green manuring, which I can say from a considerable experience in tropical agriculture is carried on in Ceylon to a much greater extent than in any other country of the world, not even excepting England. It has been developed to a very high pitch of excellence. Closely allied to this question is that of mulching, which I did not refer to in my paper, but which we are making a great point of in Peradeniya. It has the effect of keeping the soil moist, neutralising the effects of the sun, and giving nitrogenous organic matter to the soil. It is well known, of course, that if you burn a soil your first effect is to check fertility, but afterwards to produce a great increase. This has been known for two or three thousand years among cultivators, but it was never understood until recently that first of all you destroy toxins in the soil as well as fertilising bacteria, but that the latter begin to multiply again more rapidly than the poisons. Mr. Burgess raised a very interesting point, which was afterwards referred to by Mr. Crosbie Roles and Mr. Gibson, as to the term "standardisation." What is the meaning of it? I wrote out my definition, as "to ensure each commercial grade being of standard quality," but then I thought, "What does that mean?" and I put in "standard or uniform." It is for you in London to give us a definition of such terms. We do want to know what you mean. I have had considerable experience, for instance, in New Zealand,

and there, although you have a great variety in the kinds of wool, there is no difficulty in grading them in the woolshed. It is all labelled in accordance with the wishes of the buyers in this part of the world and sent to the Wool Exchange. That is what we want you to help us in doing with regard to our rubber. You cannot make uniform rubber in London. We must make it out there, but you can tell us, " We want such and such a quality. So-and-so can make it." We know precisely what our difficulties and our limitations are, and we are trying to arrive at a system by which uniform rubber can be produced. We want to reduce the variability of rubber. Dr. Lock, whose work at Peradeniya is well known probably to everyone here, and whose work we are still carrying on, pleaded for some latitude for the individual in connection with research. With that I quite agree, especially when we are groping in the dark as at present. It is only from men who have got ideas that we can ever expect progress ; but what I mean is this, that we should in all research work lay down definitely what is to be our object. We should say, " This is the goal we want to get to, this is the road we want to take to get to it," and in making our plan we should not do it alone as a Government Department, but should call in the co-operation of practical men. I should like to say in regard to Mr. Gibson's comments on my remarks concerning criticism of methods, that what I said in my paper was, " I am not suggesting that methods are not justly criticised, but what I do say is that they should be beyond criticism." Gentlemen, I am afraid we are a very long way from that in the East. I always have in my mind in research work the example of Rothamstead. If we lay down our experiments on those lines of continuity and the elimination of all subsidiary influences we should be able to arrive at conclusions by methods beyond criticism. Until we can do that our conclusions will not be of very great value. I have only to add this about the work being done at the Imperial Institute. Mr. Bruce has explained to you something about what they are doing there. They are merely doing what is being done in the factories, but anyone can see our vulcanising plant and our testing machines there under a specialist quite apart from the Imperial Institute staff. The only advantage about having it there is that you may be certain there are no other influences at work. They will give you an independent result. You cannot challenge the results of a place like the Institute as you can perhaps a manufacturer's results. You never can tell how a manufacturer is likely to be influenced by his other interests. It is of no interest to us to say that one sample is above another. We only do the vulcanising and testing there, bear in mind, then we pass on the samples, which are being prepared now in commercial sizes, to the manufacturers, and say, " Give us your opinion of these." After studying the matter very carefully I do not think that one can devise a more impartial or practical way of trying to clear up the many difficulties with which we are now confronted, and which are manifested in the variability of plantation rubber.

A
Comparison between Wild and Plantation Grown Rubber.

By

A. IRVING.

In comparing the two great sources of the world's supply of rubber, my object is to give a general resumé of the main points of difference in the methods adopted in Brazil and those of the Far East.

To begin with, we must realise the vast difference that lies between the *Hevea* tree in its native home in the valley of the Amazon and its carefully nursed and cultivated congener in Ceylon, the Federated Malay States and surrounding countries. On the one hand we have a forest tree, growing under the same conditions as other forest trees, and choked by heavy underbrush which retards its growth and makes of it a very hardy member of the forest tribe. On the other hand the plantation tree resembles more a garden product, being raised from seed carefully planted in nurseries, taken from these when six months to a year old, and set out in neat rows under conditions only obtainable by the employment of the best husbandry. The ground thenceforth is kept clear of all other forms of vegetation, unless it be some catch-crop, which is kept far enough removed from the young trees to insure non-interference with their growth. The result of these conditions is clearly shown in the great difference of time needed by wild and plantation trees in which to mature. It is difficult to say at what age the wild *Hevea* reaches the stage of profitable bearing, but from observations I have made and from information gained on the spot, twenty to thirty years seems to be the very least that could be expected to produce a tree of tappable dimensions, whereas with plantation rubber it is a frequently recorded fact that trees can be tapped profitably at the age of four years or even earlier. I have mentioned the hardiness of the wild rubber tree, and in support of this shall now endeavour to give some idea of the methods of tapping employed in the Amazon Valley, and the consequent damage which must of necessity accrue to the tree. The implement commonly in use is known as a *machadinho*, which, as its Portuguese name implies, is a small axe. This is made of iron, and has a cutting edge two to three inches in length, being mounted on a wooden handle about 18 inches to 2 feet long. I may here mention that steel is rarely if ever used, there being a prejudice which almost amounts to superstition connected with its employment. I shall try later to give some explanation of the circumstances under which this prejudice appears to have arisen, and in the meantime will proceed to describe the process of tapping as I have seen it carried out on the Amazon. The rubber collector, having armed himself with a machadinho and as many tin cups as will be necessary for his day's work, proceeds along his estrada (a path cut through the jungle), dealing with each rubber tree as it occurs. His method is to strike a blow, slanting slightly upwards, at an angle of about 45 degrees, into the bark of the tree, giving a twist of the wrist before withdrawing his axe in order to loosen the bark directly above the incision. As close as possible under the wound so made is fixed a cup, either with an adhesive clay or, more commonly, by the simple means of pressing the edge into the bark and so leaving the cup hanging to the tree. The first incision is made at about 9 ft. to 10 ft. from the ground, or as high as a man can conveniently reach with his arm fully extended and the axe handle held at the butt. A short ladder is sometimes used, but as a general rule, tapping above 10 ft. from the ground is deprecated, and in some of the Brazilian States even disallowed by law. The first incision having been made, the collector proceeds to make a rough measurement, generally of two "palms," or about 8 inches, horizontally along the tree's surface, at which distance the operation is repeated. This is continued until the whole circumference of the tree has been traversed, a cup being placed under each incision. Thus it will be seen that the number of cups a tree can carry depends largely on its girth, but it is sometimes found advisable to limit the number to the tree's bearing capacity, so that no hard and fast rule can be laid down as to the exact number of cuts that can be made on any given tree. Tapping is carried on in the same manner on succeeding days, the incisions being made directly below those cut the day previously, and the practice is continued until the base of the tree is reached. The result of this operation is to leave vertical lines of scars from the base of the tree to a height of about 10 feet. When this is completed, other rows are started in the intervening spaces of bark, and the process is continued for as long as there is any untapped bark left to work on. When the whole available surface has been used up, tapping begins again, on the same lines, over the old scars which in the meanwhile have had time to heal. After years of this work it can be easily imagined that the trees present a very unsightly appearance: the blows of the machadinho are, as a rule, not stinted, with the result that the wood is, more often than not, cut into. The healing process of these wounds creates a very rough surface, and causes the tree to increase enormously in girth, resulting eventually in its becoming much thicker at the base than above the tapping line, and giving to it a bottle-shaped appearance. There is an absence of method and care employed in the tapping of wild rubber, which frequently leads to a great deal more damage to the tree than is at all necessary. Properly conducted, the system gives good results and has many points in its favour, not the least of these being the rapidity with which the work can be carried out. This is a serious consideration where trees are often very far apart, and the paths connecting them of a nature to make walking both slow and difficult. For the better preservation of the tree, one rule I found to be almost universally adopted, *viz.*, the non-removal of scrap rubber from the incisions, the object being to prevent the ingress of borer and other pests which abound in the forests and are always on the look-out for a means of entry to the heart wood of the tree. In spite of this precaution many trees are killed yearly by the ravages of pests and disease, the result being to force the collector to find trees further afield, where greater transport difficulties heavily handicap his labours. I might here mention what has apparently led to the general aversion to the use of steel implements in the tapping of wild rubber: The iron axe, being incapable of taking a keen edge, bruises rather than cuts the bark, and it is possible that with the sharper instrument it was found that more damage was wrought to the tree by its cutting more deeply into the wood. The superstition that the mere contact of steel with the bark of the tree constitutes a danger to the latter, is, in my opinion, quite groundless. I have repeatedly been asked what reserve of matured rubber trees exists in the Amazon Valley, and my reply to this is that, though there are doubtless many millions of unworked trees in the country, their inaccessibility makes of them an unrealisable asset with raw rubber at anywhere near its present figure.

A general description of a seringal and of the estradas which compose it may not be out of place here. The name seringal, the plural of which is seringaes, comes from the Portuguese " seringa," which means a rubber tree. Most of the seringaes on the banks of the Amazon and its tributaries have been held for generations by the descendants of the pioneer owners, into whose possession they originally came by the law of " squatters' right " and by force of arms. The latter had to be employed against the wild Indian tribes which then infested the forests of the Amazon, and even up to the present day owners of properties are obliged to take such precautions as will insure them against molestation from these people. Only last year, while travelling on the Madeira river, I heard of a case in which a property had to be abandoned owing to the depredations of a warlike tribe whose attitude had become too aggressive to be pleasant. A feud has always been in existence between the Brazilian and Portuguese settlers and their uncivilised neighbours, which accounts for the fact that very few of the latter are ever to be found employed in rubber work. The boundaries of the seringaes were doubtless originally determined by the extent of the pioneer's resources, and are undefined except by natural landmarks. The only fixed limitation of a property lies in its length of river frontage, its depth being determined by the distance at which the rubber can be profitably worked. In most cases this does not exceed a few miles, owing to difficulties of transit. A seringal is formed by the cutting of estradas through the jungle, and great skill is needed for this operation, only the most expert woodsmen being employed. The paths are cut without any regard being paid to direction, the whole object being to include as many rubber trees as possible in the distance traversed. An estrada usually contains from 150 to 250 trees, and may be anything from two to four miles in length or even longer. No definite figures are obtainable as to the actual amount of rubber which can be produced annually by any given tree, the yield varying enormously according to the different varieties of trees. From my own personal observation, however, I should say that the very best specimens are capable of producing fully 100 lbs. of dry rubber per annum, while the minimum production per tree might be estimated at not less than 5 to 6 lbs. Of this difference in the quality of trees I shall have something to say later. The measurement of land in the Amazon Valley is a thing practically unknown, the size of a seringal being rated simply by the number of estradas it contains.

Now to compare the method of extracting plantation rubber, a method which, with certain modifications, has been in vogue almost as long as the plantation industry has been in existence. Here we have incisions made with a steel gouge or some similar instrument, never deep enough to injure the wood of the tree, the whole object being to keep a smooth surface on which subsequent tapping can be carried out. I shall not endeavour to give a detailed description of the operation, it being already so well known to the majority of those interested in the rubber industry; suffice it to say that the main principle consists in the daily removal of thin parings of the outer bark of the tree, the cambium or inner bark being retained as a protection to the wood, and also as a foundation for renewal of the lactiferous bark. Thus it will be seen that whereas the collector of wild rubber takes no heed concerning the future conformation of his tree, the whole object of the plantation rubber producer is to retain as closely as possible the symmetrical proportions with which nature has endowed it. The yield per acre of plantation rubber varies according to the age of the trees and to soil conditions, etc. Some 350 lbs. of dry rubber per acre is looked upon as a fair average yield per annum, and one which can be maintained without injury to the trees. This figure is often exceeded where conditions are exceptionally favourable, but for purposes of calculation it is generally conceded that 350 lbs. is a fair average to take. Trees are usually planted about 100 to 150 per acre, so that the yield per tree of plantation rubber may be safely taken at not less than 2½ to 3½ lbs., according to the distance at which they are planted.

The next point with which I propose to deal is the preparation of the raw rubber for market. The chief distinction to be drawn here lies in two particulars, the first being that in Brazil the preparation of rubber is the work of the individual collector, whereas in the East it is centralised, each estate or group of estates possessing its own factory, to which the latex, after collection, is carried. Secondly, there exists, on the one hand, the coagulation of latex by direct contact with smoke fumes, and on the other coagulation by acids, smoke being only used in some cases as a preservative after the rubber has been moulded into sheet or crépe form by mechanical processes. A brief description of the Brazilian method may here be of interest. As previously stated, the work is carried out by the collector; his apparatus consists of a cone-shaped funnel of either iron or earthenware, a large tin basin to contain the latex, a dipper for handling the same, and a stick or a paddle on which the ball of rubber is to be formed. The operation takes place in a palm leaf shed, in the centre of the earthen floor of which is cut a round hole about 18 ins. in diameter. In this a fire is laid and lighted, the funnel being placed over it. In places where it is obtainable the fuel used is the *uracuri* palm nut, famous for the amount of creosote and other preservative matter that it gives off when burnt. It is a notable fact, however, and one which is not generally known to the Eastern rubber planter, that a considerable quantity of "hard cure" rubber is produced in districts where this particular palm does not exist, a fact which dispels the generally prevailing theory that to the peculiar qualities of the *uracuri* nut is due any superiority which hard cure may have over any other form of rubber. In places where palm nuts are unobtainable, the rubber is smoked over fires composed of some hard wood, the nature of which I had no opportunity of learning. The process of making hard cure is primitive in the extreme, though some skill is needed to obtain the best results. To begin with, the smoke which issues from the funnel must be of sufficient heat and density to coagulate the latex immediately it comes in contact with it, at the same time being not so hot as to scorch the rubber. As a rule, the foundation of a ball of rubber is composed of scrap. This is first wound on to the stick, the latex being then poured over it and smoked, layer on layer, by holding it in the smoke, at the same time giving the stick a rotary movement with the hands. A few turns suffice to coagulate and thoroughly permeate each layer of latex, the process being repeated until the ball reaches the required dimensions. In cases where scrap rubber is not used as a foundation, the stick is superseded by a wooden paddle on to which the latex is directly poured, the result being to produce a ball composed entirely of hard cure, known commercially as a "knapsack." When the rubber reaches the buyer's hands it is easily dissected by means of a sharp knife, and the sections of which it is composed, each being represented by one day's work of the collector, are removed separately. A ball of rubber may have three distinct grades contained in it, *viz.*, hard cure, entre fino (an inferior grade produced by faulty preparation) and scrap, which consists of the cleanings of cups, lump rubber which has formed in the latex before it is treated, and any waste rubber which may have been picked up round the trees, etc. Scrap rubber undergoes no treatment at the hands of the collector, but is marketed just as it is picked up, and often reaches the buyer in a state of semi-putrefaction. The balls of rubber are not boxed for shipment to their destination, being merely stamped with the mark of the property from which they come, and are then loaded loose into the holds of the river steamers, which ply in considerable numbers between the seringaes and the ports of shipment. This haphazard method of shipment can certainly not be recommended, and as steamer receipts are given only for the number of balls, and not for the weight of rubber shipped, complications are apt to arise in cases where marks have become obliterated. In this connection it is interesting to note the great difference between Brazilian and Eastern methods of handling rubber: in Manáos and Para (the two great rubber centres of Brazil) one sees this valuable product lying about and treated with an apparent lack of care which to the Eastern planter would appear somewhat unsafe. It is only fair to add, however, that cases of stealing are very rare. This applies only to the towns and not to the seringaes, where stealing is of all too common occurrence, and, owing to the large area covered by most of the properties, is very difficult to suppress. The Eastern method of preparing rubber takes place, as I have previously mentioned, in factories. In these are to be found the most up-to-date machinery that is produced for the treatment of raw rubber. Coagulation of latex is, in nearly all cases, done by means of acids, and the "sponge" so formed is either passed through macerating rollers, which reduce it to the form of crépe, or is moulded in pans and formed into sheet, which is then passed through smooth rollers to express the moisture. Crépe rubber is boxed and shipped as soon as it is sufficiently dry, whereas the best sheet is only dispatched after undergoing a course of smoking which lends to it a clear amber colour and also acts as a preservative. The smoking of crépe rubber is not, as a rule, encouraged by the manufacturers. Scrap of all grades is also treated by machinery, which thoroughly cleanses it of all impurities and turns it out in crépe form. No rubber is shipped until it has been well dried, and every precaution is taken to insure its reaching the buyer free of all foreign matter and in the best condition possible. While on the subject of the preparation of raw rubber it may not be out of place to remark on the disparity of price which at present exists between hard cure and plantation rubbers. In appearance the latex from the two trees is dissimilar, in that the Brazilian product has more body in it and is of a deeper colour. Chemical analysis goes to prove, however, that there is little, if any, distinction between the two rubbers when manufactured: we must therefore look elsewhere for a reason to account for the preference given to hard cure, I think the solution is to be found in the standardisation of hard cure. which has been known to manufacturers in one unfailing form for a great number of years. Plantation, being of much more recent date, has still to prove itself capable of similar standardisation, and until this is achieved, manufacturers will naturally prefer to deal with a rubber which gives more certain results. One only has to visit a rubber broker's sample rooms to realise the immense amount of difference that can be given to the appearance of plantation rubber by variation in the addition of acid, etc., during preparation. Here we have crêpe of all shades and thicknesses, sheet smoked and unsmoked, and of varying thickness and sizes. All these, or most, are excellent of their kind, but when it is considered that each variety may have to receive different treatment at the hands of the manufacturer before being turned into rubber goods, it is only reasonable to suppose that he will show preference for the article with which he is most conversant. It may here be asked why a standard of hard cure cannot be set up for Eastern rubber, to compete with that from Brazil. The reply to this is that even supposing plantation latex could be treated by the paddle method (which is doubtful in view of its lack of density) the cumbersome nature of its operation is hardly likely to attract the Eastern rubber grower. Mechanical processes for the production of hard cure are now under trial, but whether these will ever supersede the present system of preparation is for the future to decide.

I shall now endeavour to give some impression of the conditions which prevail in the rival countries, if I may so term them, in relation to rubber properties. Most important in this connection is the question of labour, a matter which on all hands is admitted to be vital to the success of the industry. In Brazil the labour employed is both local and imported, the latter far outnumbering the former, though, from the fact that much of the imported labour becomes permanently resident in the country, annual importation in large numbers has become unnecessary in most of the rubber districts. The "truck" system, or payment in kind, is in practice everywhere, cash rarely passing hands from employer to employee. The result of this system is to create a very uncertain value in the matter of remuneration, the employer setting his own standard of payment to suit his own ideas on the subject. Rubber collectors are never paid daily wages, but are given the value in goods on a certain proportion of the rubber which they bring in. This proportion varies according to the prices charged for provisions, etc., the supply of which is invariably in the hands of the employer. For instance, I have known two adjoining properties, on one of which the employee was allowed 50 per cent. of the rubber he collected, goods being charged at the rate of 100 per cent. profit to the employer, while his neighbour was allowing 75 per cent. of rubber and charging a price for provisions which left in his hands a profit of close on 200 per cent. As a set-off to this apparent hardship to the collector, such heavy taxation on the necessities of life seeming, on the face of it, to be grossly unfair, must be put the fact that he has got to be supplied with provisions when incapacitated from working. This, in a country all too notorious for its unhealthiness, is often a heavy tax on the employer, frequently resulting in his incurring great loss through bad debts. A case of this kind was pointed out to me on one seringal, the books of which showed the enormous sum of £1,300 standing to the debit of one individual. The cost of importing labour works out, roughly, at £30 per head, only a small proportion of which, if any, is ever recovered. The labourer being paid as he is on results, practically becomes a partner in the business, and takes quite as much interest in the fluctuation of the price of rubber as his employer. His work often takes him a considerable distance from headquarters, and supervision being of necessity inadequate, he is, as often as not, a law unto himself. His only duties, in addition to tapping his rubber, are to keep his estrada cleared and his house, etc., in repair. These works he is obliged to perform gratis. I have mentioned elsewhere the stealing of rubber on seringaes; on large and scattered properties this is a great evil, and one which it is most difficult to suppress. The illicit selling of rubber by collectors is made easier by the fact that there are often to be found steamers, run by unscrupulous merchants, plying for trade on the rivers. These men are generally willing to barter goods for rubber without inquiring too closely into the rights of ownership. The class of labour employed is not of a very tractable disposition, and, the arm of the law being weak in these out-of-the-way parts, the employer has often to wink at offences which, in a more civilised locality, would not go unpunished. The amount of rubber that it is possible for a collector to produce in a day depends largely on his capacity as a workman, and also on the class of estrada that has been given him to work. It is perhaps superfluous to remark that the best yielding estradas are apportioned to the best workmen, so that the difference between the earnings of the skilful and the inexperienced man is very marked. I have known of cases where good tappers have been able to collect as much as four kilos of dry rubber a day, and in more inaccessible districts where the trees have only been lightly worked, I have heard of as much as 20 kilos being extracted. On an average, however, I doubt if more than two kilos is collected, and of this 10 per cent. has to be deducted for loss of weight in transport. This does not include scrap rubber, which, as a rule, is collected in such small quantities as to be almost negligible. With rubber at 3s. per lb. on the London market, the price in Brazil works out at about Rs.3,600 (equal to about 4s. 8½d. English money) per kilo. Thus, the earnings of a man who collects two kilos of No. 1 dry rubber a day will not exceed 4s. 4d., allowing for a 10 per cent. deduction for loss of weight. This is on the basis of a 50 per cent. division between him and his employer, and it must then be recollected that he has to pay double value for all goods which he receives in payment, so that his nett earnings practically do not exceed 2s. a day. As a rule the labourer is not encouraged to raise his own foodstuffs by his employer, who prefers to sell him what he needs at profit to himself, but in any case his time is generally too well occupied to leave much leisure for garden work, and the only local additions which he makes to his larder are the fish and game which he is able to obtain from the rivers and jungle. When it is considered that the collector generally has a wife and family dependent on him, it can hardly be said that his lot is a particularly enviable one. Most of the seringaes are worked by their owners, who reside on their properties and make themselves as comfortable as circumstances will permit. Their chief occupation consists in dealing out provisions to the rubber collectors, who bring in the rubber weekly, returning to their estradas with sufficient rations to carry them over the succeeding week. The class of goods for sale to the employees varies, and is a sure indication of the state of the rubber market. For instance, during the boom of 1910 the rubber collector was able to purchase anything from gramophones to kid boots, whereas in the present state of the market little else but the stern necessities of life are to be found in the stores, and in some of them not too great an abundance even of these. In addition to his duties of shopkeeper, the owner or manager attends to the shipment of his rubber and pays occasional visits to his estradas to superintend the work that is being done in them. He is usually financed by a firm of Aviadores (or merchants) in Manáos or Para, who supply him with the goods he needs, and receive and attend to the selling of his rubber, reimbursing themselves out of the proceeds for the value of goods supplied. The seringal owners frequently get heavily into debt to these Aviadores, on whom they then become dependent for the means of living, and many seringaes arrive at being so heavily encumbered in this way that their owners can be so called in name only.

The Eastern plantation labour is run on completely different lines from the Brazilian, being, in the first place, employed entirely on daily wages. The truck system is practically non-existent and in no case does the employer seek to make a profit out of goods supplied to his coolies. These are generally imported, in the case of Ceylon from Southern India, and of the Federated Malay States from Southern India, China and Java, local labour being used only to a limited extent in either country. Organisations are formed both by Governmental and private enterprise for the proper protection of imported labourers, with the result that their well-being is carefully studied. Wages rates vary considerably according to country and local conditions, and are best judged by the fact that rubber can be tapped for as little as 3d. per lb., the rate rarely exceeding 6d. even in the most unfavoured districts, where from unhealthiness and other causes labour is difficult to obtain, and consequently more expensive. The management of rubber estates is conducted by men thoroughly trained in the business, who in turn are overlooked by visiting agents, these being employed by the owners to give special expert advice. Most of the properties are owned by companies having their head-quarters either in England or on the Continent. The balance of ownership lies in the hands of local companies or private enterprise.

Having described to the best of my ability the difference in conditions which exist in Brazil and the Far East, I shall now proceed to what may be considered the crux of the whole position, *viz.*, the cost at which rubber can be produced. I have frequently been asked whether it is true that Brazil would be unable to produce rubber with the price below 3s. per lb., and if not, at what price that country would be forced from the field. I think that in the very nature of things the Brazilian industry will die very hard, if it ever does so at all. The sole occupation of the people in the Northern States of Brazil is connected with the rubber industry, and with no other means of livelihood at hand it is hardly probable that they will abandon their one means of support as long as there is sufficient in it to eke out even the barest living. That they are able to do this with rubber at 3s. per lb. is well proved by the fact that rubber is being produced to-day in only slightly less quantities than formerly. The tendency of late years has unquestionably been to overtap the trees; in the boom year in order to get as much rubber as possible at the high price then prevailing, and, latterly, to increase the quantity of rubber collected in order to be able to meet expenses. The result of this recklessness has been to kill out a good number of trees, thereby handicapping the collectors severely. But there are still plenty of workable trees left, and so long as these remain they will certainly be tapped. Economy is a lesson still to be learnt in Brazil, not only by the rubber workers, but by everyone connected with the country. The Government awoke to this fact a year or more ago, when they reduced the duty on raw rubber, and there seems no reason to suppose that the duty cannot be further taken off should it be found that the industry is unable to survive, burdened as it still is with the enormous duty of 21½ per cent. *ad valorem.* Not only is there this heavy export tax in existence, but the tariff on imports also adds largely to the expense of living. This heavy taxation is bound to be reduced automatically as the industry shows signs of waning, and though production is likely to decrease gradually during the next few years, it must take a long time of the very acutest depression to place Brazil "hors de combat" among the rubber producing countries. Apart from the question of taxation, economies can, and undoubtedly will, be effected by the rubber producers themselves in the matter of living. For instance, the raising of foodstuffs locally is a problem which is already exercising the minds of those who have the welfare of the industry at heart. For a long time the Brazilian was inclined to treat the plantation rubber as a factor not to be seriously reckoned with, but he has now awakened to the fact that he has a rival in the field who is not to be ignored, and recognises the necessity of setting his house in order. Plantation rubber growers also cannot be held blameless in the matter of reckless expenditure in the past, and anyone who has had the opportunity of comparing the methods employed in 1910 with those of the present day is able to judge of the reforms that have been made in this respect. It is now generally conceded that the all-in cost of producing rubber in Ceylon and the Federated Malay States should not exceed 1s. per pound, and many cases are extant where even this figure has been improved upon.

It now only remains for me to draw such conclusions as the study I have been able to make of the rival industries has suggested to me. That the methods employed in one country might be applicable to the other to anything but a very limited extent, I am very much inclined to doubt. Only last year I was employed on a Commission which was engaged for the purpose of introducing Eastern methods of tapping in Brazil. The result went conclusively to prove the futility of the proceeding, due entirely to the different conditions under which the trees are grown. The method of tapping the plantation tree, though doubtless more scientific than that used on the Amazon, is not suited to the forest tree, which for so many years past has shown itself capable of withstanding the apparently rough treatment which has been meted out to it. Brazil has certainly a good deal to learn from its Eastern rival in the matter of organisation, more especially in the management and control of labour, but here again the conditions are so much at variance that it is doubtful if what can be applied to the one would necessarily suit the other.

I have mentioned elsewhere the different varieties of rubber trees that are to be found in the jungles of the Amazon. I have known as many as six different varieties of the *Hevea* species to exist in one estrada alone, and of these perhaps not more than two would be really prolific yielders. In the East, as far as we know, not more than one variety exists, and this is certainly not the one looked upon as the best in Brazil. This is the "Preta," or black tree, which is an exceedingly fine yielder, and by far the best variety of tree known. As to whether this tree would have had the same success in the East as the "Branca," or white variety, which exists there, is a matter which can only be decided by experiment, but of the superiority of the former in the Amazon Valley there can be no question. Of other lessons that either country may be able to teach the other, I can think only of the process of rubber preparation. I have already mentioned this as it affects the East, and in condemning the Eastern method in Brazil it is sufficient to say that the scattered nature of the properties makes the establishment of factories impracticable, and without these the Eastern form of manufacture becomes impossible.

In conclusion, I have only to remark that this paper is not meant to be critical of the methods of either country concerned, neither is it to be thought that my object has been to draw any odious comparisons.

It must always be borne in mind that Brazil is the father of the rubber industry, and if some of the methods may appear on the surface to be slip-shod and unsatisfactory, there is always the fact in the background that they have proved efficient for many years past, and it is hardly to be wondered at if the present generation is slow to grasp the necessity of moving with the times. The plantation industry, on the other hand, is in its infancy, and although it has already been put to the severe test of a change from great opulence to a comparatively obscure position in the commercial world, it has nevertheless succeeded in holding its own in a very marked degree, and with the energy and foresight which those concerned in it continue to show, there can be no question as regards its future success.

The CHAIRMAN: I think we will all agree that we have listened to a very interesting and valuable paper. The point about the method of the tapping of the trees in Brazil is a very important one. The merits of that method of tapping can hardly be discussed on any but a very broad basis, because of the difference between the tree as it occurs in forests—I am speaking from hearsay and not from personal observation—and on plantations. I have been given to understand that owing to the peculiar methods of growth in Brazil there is a great difference in the bark. That of the trees on the Eastern plantations is much smoother than that of the forest trees. I believe that is one reason why the Eastern method of tapping would not apply there, and why the tapping with a small knife has proved efficient for a large number of years. I should like to ask Mr. Irving whether these slowly grown trees suffer abnormal enlargements and show the bad effects of overtapping to the same extent as in the plantation trees.

Mr. IRVING: Do you mean when the hatchet is used? You get a much greater enlargement in that case. It creates a false surface not only of the bark but of the wood itself.

The CHAIRMAN: So that the enlargement of the trees tapped for a number of years is very conspicuous.

Mr. IRVING: Very conspicuous indeed.

Mr. STAFFORD WHITBY: With reference to the character of the bark. I met a Sumatra planter who had been to the Amazon for some French company, and he told me that the bark was so frightfully hard on some of the trees that the gouges used in the East simply broke on it. He attributed this to the fact of the slow growth of the trees. A tree that in the East would be ten years old would be equal in point of size to a tree 50 years old in Brazil. I am inclined to think there is something in that, because I have noticed that in 15-year-old trees in the Federated Malay States, if the tree is tapped quite high up, where the bark has never been tapped before, it is frightfully hard. With regard to the structure of the bark in slow growing trees, I have noticed quite definitely with trees that grow slowly in plantations—there are quite distinct variations—that very often the bark is of an extremely open character owing to the slow growing nature, and there is a lot of cork.

The CHAIRMAN: Suppose the tree itself becomes corky, by what means is it treated to make it suitable for tapping?

Mr. STAFFORD WHITBY: Such a tree would be slow growing and small, and nowadays most of the areas planted some years ago have been thinned out, so that the corky tree would be thinned out. Otherwise you would scrape the surface you are going to tap.

Mr. IRVING: In reply to the question about the bark formation, there can be no question whatever that the bark gets extremely hard on these very old trees, and of abnormal thickness. I have noticed, on these big wild trees, bark above the tapping area that is never touched at all which reaches 1 inch and 1½ inches in thickness. In our experiments out there we broke gouges by the hundred, and we had very poor results indeed. If you go above the tapping surface you are doing a thing prohibited by law, because in that country they have a superstition that if you tap above a certain height you are damaging the tree. I was allowed to do it under certain circumstances without being shot at, however, and I found that the bark was extremely hard and close-grained.

Mr. B. D. PORRITT: Is there no difference in growth of the different varieties of *Hevea*?

Mr. IRVING: You can get no information whatever from anybody as to the rate of growth of the wild rubber trees. One's own observation in a very short space of time cannot give any help. As far as I can see, the tree must be every bit of fifty years old before you can tap it at all; probably a great deal more.

Mr. HEINRICH KOENIG: In previous years there was a large margin for reducing the cost of production of the Brazilian rubber. Have you any figures as to the prices they asked from the people four years ago for their supplies, and the prices now?

Mr. IRVING: In the last four or five years the increase has been by about 100 per cent. It is all imported stuff, and practically nothing is produced locally.

Mr. KOENIG: Do not these aviadores make very large profits?

Mr. IRVING: Yes, they make enormous profits provided they get paid, but they get very badly hit very often through bad debts.

Mr. KOENIG: But if the aviadores did not take such high profits the cost of production could be reduced.

Mr. IRVING: Yes, but first of all the very heavy import duty that exists at present must be eliminated. As long as you have a "truck" system of payment entirely in kind, naturally the higher your goods are the more the cost of production is going to be. That is the case out there now; the price of goods is so high that it is most difficult to make a living out of rubber itself at its present prices.

The CHAIRMAN: What is the nature of the food supplies?

Mr. IRVING: Dried meat mostly, and also very largely *feringe*, which is a product coming from the manioc.

The CHAIRMAN: There will be possibilities as to local production?

Mr. IRVING: Yes, it is a country that would give anything, if only labour were cheaper and the stuffs could be supplied in sufficient quantities to supply the demand of all the rubber-producing people.

Dr. SLOCUM: Mr. Irving repeated his statement that there was a big difference between the trees. We understood that the Chief Botanist of the Brazilian Government inspected the Eastern plantations and reported that the trees were practically the same.

The CHAIRMAN: Was that Dr. Huber?

Dr. SLOCUM: Yes.

Mr. IRVING: Well, I can state most definitely, that is not the case. I saw as many as six varieties all growing together. The black tree out there is the most wonderful milk-giving tree I have ever seen. If we produced anything like it, we would have been able to make so much rubber that it would have flooded the world.

Dr. ESCH: Our friend, Dr. Cerquiera Pinto, who is known to most of us by this time, has been working for a long time on the improvement of the rubber from these trees. He stated to me a month ago that he has a very easy means of finding out from the latex if the tree is the best variety in the Amazon or one grown in the Eastern plantations. He tells me that with his special coagulant you are able to say whether you have latex from the Brazilian tree or whether it is from the Ceylon tree, because of the different colours which these different kinds of latex show after mixing with his reagent. Probably it would be due to the use of carbonate of guayacol, which from the smell can be easily detected in his coagulant.

The CHAIRMAN: I have a sort of recollection that the last time we discussed this matter Mr. Wickham contributed some remarks, and to the best of my recollection he stated most unequivocally that the Eastern plantation trees were the same as the best of the Brazilian trees.

Mr. IRVING: I do not for one instant want to contradict such an expert as Mr. Wickham. At the same time I was told that the rubber seed which he collected was collected in a district in which the black variety of tree, which they look on as the best variety, was not in existence at all. They say it was quite impossible for him to obtain that variety. That is the information I got on the spot from the Brazilians themselves.

Dr. SLOCUM: I asked my question for information. There is little chance of producing an article equal to the Brazilian if the article was not right to start with.

Mr. IRVING: I do not want to imply that if we have an inferior yielding tree we have an inferior quality. I would not like to say that the difference in quality is due to our not having the best tree. I am talking of appearance and the amount produced.

Mr. STAFFORD WHITBY: I would like to know something more regarding Dr. Pinto's claim that he can distinguish latex in such a manner, after the use of his coagulant, as to know whether it comes from the best Brazilian trees or from the plantations. Of course, preservatives were used?

Dr. ESCH: He got the preserved latex from Ceylon, and he told me that he has now on his stand one cup of preserved latex from Ceylon and another sent from Brazil, also preserved; but his Brazilian latex is not the one that he wished to obtain. They must have given him the wrong stuff. He tells me that he has made these experiments for many years. On this matter of the variety of trees, I have heard Dr. Huber himself state that the variety of trees found on the Eastern estates are not those recognised as the best in the Amazon Valley. I do not know where you have obtained the other information concerning Dr. Huber's opinion—he personally told me they have not got the same tree.

Dr. SLOCUM: The information is in the doctor's official report to the Brazilian Government. About the matter of the reagent as a means of discovering the particular kind of tree the latex comes from, guayacol is recognised universally as a coagulant. Mr. Whitby has used it, for instance, on the oxidising enzymes in latex from different parts of the trunk, and his work shows that you can determine what part of the bark the latex has been taken from. The upper part of the bark gives much more coloration, showing the presence of lignose bodies and such. Therefore, Dr. Pinto's statement that he can tell what tree the latex is taken from is substantially incorrect.

Some Notes on the Manuring of Rubber.

By

HAROLD HAMEL SMITH

(*Editor of " Tropical Life "*).

Those who were present at the reading of the paper by Dr. Lierke on the Manuring of Rubber Trees, at the Congress held in this building in 1911, may remember that in the discussion which followed his paper I maintained that both in the planting and the manuring of the trees the main object to be attained was to have a fewer number of trees of larger girth rather than a greater number of a comparatively small diameter, and therefore, with a smaller area of bark to each tree. At that time, the tendency was to plant trees as close together as 400 to the acre, with the idea, I believe, of thinning them out in time until they stood at only 200 to the acre, that is to say, about 12 by 18 feet apart ; to-day I understand that those in whose policy I have the most confidence are discussing such distances as :—18 by 24, 24 by 24, and even 30 by 30, giving 100, 75, and 48 or 50 trees only to the acre. This indicates that the policy I advocated in 1911 has been found, in the end, likely to give the largest amount of rubber per acre.

Commenting on the Annual Report of the Plantation Association of Ceylon, " The Joint Stock Companies' Journal," of London, stated that the report contained some interesting particulars of the progress of rubber cultivation in the Island. In it we are told that the thinning out of closely planted areas has become general, and clearings are being reduced to 125 and even 100 trees per acre, it having been clearly proved that close planting not only is a check on the yield and on the normal growth and development of the rubber tree, but induces canker and disease generally. Much harm was done originally in valuing properties on the number of trees planted, resulting in overcrowding and subsequent defoliation of trees, coupled with short yields and poor renewal of bark ; it is hoped, however, that thinning out by selection, with generous applications of manure, will in a great measure restore the affected areas in older, and prevent like damage in younger, clearings ; though it can never produce the natural spread of foliage and development of trunk area to be seen on isolated or originally widely planted trees.

Cultivation has become even more general as undoubtedly assisting bark renewal and development of the trees, and thereby tending to keep up, if not increase, the yield. The cost of production has come down considerably, and, with new areas coming into bearing and increased crops, this will be still further reduced.

This I would maintain is due to planters finding that not only is the larger girth of the trees an advantage but also, on account of the more wide-spreading crown of leaves at the top, they obtain larger yields from the wider-planted areas. The greater space, I understand, is necessary to enable the trees to re-form their bark more quickly and perfectly than can be done if the trees are planted closely together and have to struggle, not only to flourish and expand as we want them to, but for their very existence; without sufficient space even at the best of times they have no room for their foliage to develop in the open air. This is a most important matter and I hope that in the discussion to follow, those who have had practical experience, both of close and wide planting, will give us the benefit of their views on the subject, and show us, according to the latest results obtained, what is, to-day, considered to be the most advantageous distance at which to plant the trees, and the reasons that have led them to the conclusion that wider planting gives better results than were expected 3 or 4 years ago.

I have given these details because when setting out to manure your estate the requirements of the trees is of great importance, for if you wish to have them with a large amount of foliage and good thick bark you would have to modify the formula of your manures in order to secure the wood and leaf necessary to bring this about. From what I understand of manures, potash is mainly instrumental in building up the framework of the tree, and therefore this ingredient will have to be included in any complete or other manures that are used on the rubber field, both to stimulate the bark growth above ground and the root growth underneath. Mr. Lock has just told us that the bark can only be removed at the cost of much plant-food and energy and that the renewal of the bark is assisted by careful cultivation and manuring. If, therefore, these are not given, the intervals of rest necessary, if the tree is ever to properly reform its bark, may become longer than is profitable to the pockets of the producers. To assist in this reformation of bark, therefore, I take it that potash must be included in all or nearly all rubber manures as it aids the formation of fibre and wood below and above the ground. Above the ground nitrogen stimulates the growth of leaf and stem and a deficiency of this food results in stunted growth and a more or less undeveloped, because insufficiently nourished crop. Nitrate of soda in some cases has increased the moisture content of the soil and, with Ceara rubber in Hawaii, when applied just before tapping, stimulated and increased the yield. Phosphoric acid on the other hand is more particularly identified with root formation in the early stages of growth and with hastening maturity and in seed formation later on. The next question to be considered will concern the possibility of increasing the rubber content of the latex; you will note that I use the term "rubber content," because with some trees you can get a larger flow of latex which, on coagulation, proves to be somewhat deficient in its rubber content; and in such cases it might be necessary to alter your formula in order to encourage the increased percentage of rubber, if it is found possible to do so.

In the manuring of all orchard crops, it must be borne in mind that not only have you got to replace in the soil the plant foods taken away permanently by the crops, but you have also to give the trees adequate nourishment to increase their own growth and maintain their vigour, as well as to withstand any disease that may be in their neighbourhood. Analysis, therefore, of the crops alone is not a sufficient guide as to the proper formula to choose for the area to be manured. Should diseased trees be in the vicinity of healthy ones, it has (as in the case of cacao) been found extremely advantageous to give the trees a small dose of nitrate of soda or sulphate of ammonia in order to stimulate their growth, as by these means they seem able to throw off the disease that would otherwise attack them. I cannot say that this has ever been done in the case of rubber, but I remember an instance when it was done by accident in the case of cacao, and it was considered that the double dose of manure which the trees received caused them to avoid an attack of dieback which was attacking the surrounding ones. It would also be interesting to hear whether experiments on similar lines have been carried out with nitrolim. The lime which this fertilizer contains, as well as its nitrogen contents, might prove valuable to the trees and their output of rubber.

As regards the distances at which the trees are planted, it was Mr. Rudolph Anstead, I think, who pointed out some time ago, when undertaking manurial experiments on the Malabar Coast, that the trees on the rubber estate on which he was at work needed to be thinned out, as the network of roots in the soil, and the interference of the crowns of the trees planted too close together (rows 20 ft. and trees 10 ft. apart), had been found to diminish the yield of latex, and, consequently, the profits accruing from the estate. A friend of mine who was recently travelling in Malaya told me that he had met with several managers on rubber estates who had been carrying out experiments with fertilizers, but so far as he noticed there was no system in the methods adopted. For instance, it seemed at times as if those who were using the fertilizers had no knowledge of their component parts, whilst others seemed to gauge the results rather by guesswork than by reliable tables of figures jotted down month by month or year by year. My friend made this statement because, when he tried to ascertain the exact influence on the quantity and quality of the latex, no figures could be found to supply him with the desired information. As the increased yield of rubber is the main thing we are fighting for, managers, in carrying out experiments, should arrange to keep a careful note of the results both for and against the particular formula in use, for it is quite certain that the whole question of manuring rubber is still in its infancy, and it is only by keeping a careful record of the results and comparing the different formulas used that we can find out which constitutes the best manure under individual circumstances, and which formula suits each district, according to its rainfall and soil contents. The rainfall is certainly an important item, and so is the water content of the soil, for, as I pointed out in my book on "Coconut Cultivation," water must be constantly at the disposal of the plant—whether coconuts or any other crop—to convey in solution the mineral, nitrogenous, and other foods that go to build up the tree. The quantity of mineral food which a tree takes up is roughly proportional to the amount of water which it absorbs. Increasing the plants' water supply then has the same effect as supplying the fertilizers to the ground; in any case, in proportion to the water will be the benefit of the fertilizers to the trees and crop.

In stimulating the growth and vigour of the tree, this must, of course, be done with knowledge and care, otherwise you can soon exhaust it or render it too delicate to last. The roots especially should be encouraged to expand and spread downwards as much as possible, since surface feeders suffer from drought. The giant tree at Heneratgoda may, it has been claimed, owe its abundant yield (I think it gave 275 lbs. dry rubber in 3½ years) to the depth of its roots, which Mr. Lyne suggests may have tapped a water supply deep down in the soil that other trees could not reach. Again, deep rooted trees are better able to withstand strong winds and so prevent the catastrophe that overtook some of Wickham's original trees in Ceylon, when in last June (1913) some thirty or more were blown down, the roots being unable to hold them up against the strong winds then prevailing.

Before offering any suggestions as to the formulas to be used, I would like to quote a few particulars gathered from last month's exchanges as to the results obtained by estates that could be described as believers in the manuring of rubber. According to the report of the Talgaswela Tea and Rubber Co., of Ceylon, which declared a dividend of 55 per cent., this Company had an excellent year for rubber, their crop costing them 78 cents per lb., including 14 cents for the upkeep of rubber not in bearing, and for manuring. The Sittgama Rubber Co. also spent on manuring 14 cents per lb. of rubber obtained, and seemed well content with the results of the year's output.

Leaving rubber for a moment, the Great Western Tea Co. of Ceylon, which declared 17 per cent. dividend, and secured the biggest crop on record for their last year's output, *viz.*, 643 lbs. per acre, against 630 lbs. in 1912 (as compared with the average yield of tea per acre, which I understand on the authority of the "Planter's Chronicle" is between 140 and 150 lbs. per acre), manured their land with basic slag and sulphate of potash. Those, therefore, either having tea planted alone, or inter-planted with rubber, should bear this in mind, with a view to considering the use of these two fertilizers in any formulas that they may make up. The Neuchatel Estate, in Ceylon, which paid 24 per cent. dividend, produced 591,041 lbs. of tea, at a cost of 25·75 cents, including 5·18 cents for cultivation and manuring. Against this, the net price realised was 49·29 cents per lb.; the same Company produced 403,032 lbs. of rubber, at a cost of 58·28 cents per lb., including 16·52 cents per lb. for artificial manuring and cultivation, whilst the net price realised was 1 rupee 82 cents per lb., and estimates for the coming year included 18·44 cents per lb. of rubber to be raised for cultivation and manuring. The Directors of the Kuruivita Rubber Co. estimated that out of a total expenditure on their estate of 10,602 rupees, some 2,934 rupees would be required for manuring a field of 86 acres; they added that the growth of the rubber was all that could be desired, and as it was their intention to manure the rubber regularly, they had no fear but that in due course the whole area would give remunerative yields. Here, therefore, we have an example of firm believers in manuring rubber. Discussing the vexed question of tea-cum-rubber, Mr. Joseph Fraser, the well-known Visiting Agent, is reported to have said: "Tea under rubber is being largely cut out, but with the generally more liberal manuring and cultivation of the tea areas, and with the increasing areas coming into bearing, there should be no falling off in the general output from the Island (Ceylon)."

In the face of what I have said and of similar information that comes in by the tropical mails week by week, I maintain:—

1. That it pays, and pays well, to manure rubber and tea either when planted alone or inter-planted.

2. That, as regards rubber, the main object to be achieved is to develop trees of large girth surmounted with a vigorous and well balanced crown of foliage of considerable area, but not straggling, as then they would interfere with each other and diminish the yield.

3. To obtain such trees they must not be planted more than 100 to the acre, and it may yet be found to pay best to plant them, the same as coconuts, 30 by 30, or 48 to the acre.

4. That all formulas for manuring the areas must be made to suit individual cases, some areas needing the roots being stimulated to encourage them to go down to the moisture, others requiring bark-formation to be encouraged, a third estate needing invigoration for the leaves and latex.

5. Careful attention should be devoted to the roots especially with a view to driving them downwards after the moisture, lest in times of drought the tree falls away and dies through being too much of a surface feeder, or, with high winds about, is blown down and killed.

For those who care to study detailed formulas I have included the following as a basis to experiment with on the various crops mentioned. Some of the mixtures have been tried, whilst others are only recommended. I will begin with the particulars of a series of manurial experiments with Ceará rubber, carried out on the Longuza Estate of the German East African Company. Here the experimental area is about 350 metres (about 1,130 feet) above sea-level; the soil is described as being quite uniform throughout. The trees, which were planted in 1908, stand 4 by 4 metres (13 feet) apart or 250 to the acre, whilst the number of trees on each of the experimental plots (the sizes of which are not given, so I take it all the trees stand 13 by 13 feet) were as under :—

Plot	G.A.	contained	55 trees.
,,	G.B.	,,	59 ,,
,,	G.C.	,,	58 ,,
,,	G.D.	,,	54 ,,
,,	O.	,,	53 ,,

The fertilizers were applied in October, 1911, in the following proportions and manner. The soil within 1 metre of the trunk of each tree was loosened and the manure applied well mixed up with the soil within that space. The trees on the unmanured plot O. received the same treatment as the other trees—only, of course, no manure was given to them. As shown above, the trees were Ceará (*M. Glaziovii*) and they were tapped on the well-known Lewa method.

No. of Plot.	Kind of Manure.	Quantity per acre. cwts.	lbs.
G.A.	Sulphate of Potash (49·7% K_2O)	1	66
	Superphosphate (18% P_2O_5)	1	49
	Bone Meal (28·1%)	0	62
	Sulphate of Ammonia (20·5%)	1	75
G.B.	Sulphate of Potash Magnesia (26·5% K_2O)	3	3
	Superphosphate	1	49
	Bone Meal	0	62
	Sulphate of Ammonia	1	75
G.C.	Superphosphate	1	49
	Bone Meal	0	62
	Sulphate of Ammonia	1	75
G.D.	Sulphate of Potash	1	66
	Superphosphate	1	49
	Bone Meal	0	62
	Sulphate of Ammonia	1	75
	Lime	7	108
O.	———	—	—

AVERAGE CIRCUMFERENCE OF TREES WHEN TAPPED (IN CMS.)

Plot No.	October, 1911.	March, 1912.	October, 1912.	October, 1913.	Total Increase since October, 1911.
G.A.	31·7	37·0	43·0	49·3	17·6 cms.
G.B.	34·5	37·0	41·7	50·1	15·6 „
G.C.	35·2	38·5	41·0	49·5	14·3 „
G.D.	33·1	37·5	40·0	50·1	17·0 „
O.	32·6	35·0	38·0	47·8	15·2 „

AVERAGE YIELD OF DRY RUBBER PER TREE (IN GRAMS) AT DATES MENTIONED.

Plot No.	March, 1912.	Oct., 1912.	Oct., 1913.	Total.
G.A.	95·2	59·0	63·9	218·1 grms.
G.B.	60·2	60·0	57·5	177·7 „
G.C.	75·7	58·5	65·4	199·6 „
G.D.	61·7	63·0	68·0	193·7 „
O.	50·8	48·0	44·4	143·2 „

Leaving German East Africa, and coming to tea-cum-rubber estates, I am told that competent authorities in Ceylon have recommended the following, for tea planted alone, per acre :—

225 lb.	Ground-nut Cake.
225 „	Fish Manure.
100 „	Nitrolim.
100 „	Superphosphate or 125 lb. Basic Slag.
75 „	Muriate of Potash.

This, it is reckoned, represents an approximate supply of plant food per acre of :—

44 lb.	Nitrogen.
37½ „	Potash.
27 „	Phosphoric Acid.

For rubber, it is contended, the potash should be increased to 50 lb. (pure) say 100 lb. muriate of potash, the nitrogen and phosphoric acid remaining the same. For cacao in bearing the same authorities have recommended :—

300 lb.	Superphosphates or 400 lb. Basic Slag.
200 „	Nitrolim.
300 „	Kainit.

The above (cacao mixture) to be applied at the rate of 3 lb. per tree. For coconuts in bearing a dressing of 15 lb. per tree, made up as follows, is suggested :—

6 lb.	Fish Manure.
1 „	Nitrolim.
3 „	Basic Slag.
5 „	Kainit.

As regards the manuring of rubber trees in the Federated Malay States Mr. B. J. Eaton, Agricultural Chemist to the Government at Kuala Lumpur, tells us that out there* the soils are usually rich in nitrogen, although this constituent may not be in a readily available form, owing to the sourness of many of the soils when first brought into cultivation from virgin jungle, this being especially so in the low-lying coast districts. Lime, potash, and phosphate are generally very deficient.† In spite of the richness of the soil of many rubber estates, there are marked exceptions where the soil may be described as very poor, and where the growth of the trees is very slow. He recommends the following mixtures :—

For loam soils of average quality, ammonium sulphate, 150 lbs. per acre ; potassium sulphate, 150 lbs. per acre ; double superphosphate, 150 lbs. per acre ; lime, 500 lbs. per acre. The lime should be applied about one month before the other manures. The other manures may be mixed together, and mixed with earth and spread. In subsequent years half the ammonium sulphate can be replaced by organic nitrogenous manures, oil cake, blood meal, etc., and the superphosphate by bone meal or phosphatic guano.

For clay soils one half of the ammonium sulphate might suitably be replaced by oil cake—using quantities containing an amount of nitrogen equivalent to that in the ammonium sulphate replaced. The superphosphate should be replaced by basic slag or guano—preferably the former. Potash salts may frequently be omitted. Lime should be applied at the rate of 1,500–2,000 lbs. per acre.

In sandy soils at least half of the ammonium sulphate should be replaced by organic nitrogenous manures—*i.e.*, oil cake, etc., using a quality of cake containing nitrogen equivalent to the 150 lbs. of ammonium sulphate, as sandy soils are often very deficient in nitrogen. Potash salts (chloride or sulphate of potash) should be applied at the rate of 200–250 lbs. per acre. Basic slag is preferable to superphosphate, as a source of phosphates. Lime should be applied at the rate of 1,000 lbs. per acre.

In peaty soils nitrogenous manures may be generally omitted, or, if used, a small quantity of sodium or potash nitrate—say 100 lbs. per acre—might be applied, as ammonium sulphate tends to produce acidity. Phosphates should be applied preferably as basic slag or guano. Potash salts may be applied as in the case of loam soils. Lime is especially important, and should be applied at the rate of 2,000–3,000 lbs. per acre.

There are one or two points, still quoting Mr. Eaton, which it may be advisable to emphasise, as they may not be generally known, in connection with the use of fertilisers for rubber trees :—

(1) The first application of any fertiliser usually produces the greatest increase in yield, subsequent treatments producing a gradually diminishing increase till a level is reached ;

(2) Double the increase is not necessarily obtained by doubling the amount of manure applied.

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* See " Fertilisers " of March 2nd, 1912.

† Planters must, therefore, before applying fertilisers, ascertain if the trees or soil should not receive a dressing of lime first. Note the importance that Mr. Eaton attaches to lime, and Mr. Baxendale's remarks in the discussion.

These points explain why excessive expenditure on fertilisers in connection with crops of low price is not justified. The more valuable the crop, the greater the amount—to a certain limit—that can be profitably expended on fertilisers, and this principle particularly applies in the case of Pará rubber cultivation at the present time. The problem of manuring as applied to Pará rubber trees is somewhat different from that of an annual crop such as roots, cereals, vegetables, etc., and resembles the cultivation of fruit trees. Pará rubber trees, like fruit trees, require a prolonged preliminary period of growth before any crop is obtained, and growth still continues while the tree is fruiting and being tapped, whereas, with an annual crop, growth ceases when the plant ripens. We are dealing also with a continuous cropping of one kind, thus removing the same proportion of plant food every year. Nothing except the constituents in the fallen leaves is returned to the soil. General principles still apply, however, in this cultivation, since it is essential to replace the constituents removed from the soil, and to maintain the general health and vigour of the plant; any treatment which increases the girth of the tree also enables it to be tapped at an earlier age.

Discussing the quantity to be applied per tree, the Anglo-Continental Guano Works of London, who suggest for rubber trees a mixture which contains :—

4% Ammonia,
24% Total Phosphate,
10% Soluble Phosphate,
7% Pure Potash,

tell us that Dr. Voelcker's views are as follows :—" In answer to your enquiry, it is rather difficult to say what quantity of manure should be put per tree of the rubber plant, inasmuch as there is considerable variation in regard to the number of trees grown per acre. Thus we find that, while in some cases less than 100 trees are planted per acre, in others the number goes up to 300. As a general rule, however, 200 trees or rather less may be taken as the average. Taking this figure as the basis, we would say that from 2 to 3 lbs. per tree would be the right quantity to use.

" As to the time of application, this would require to be regulated by the time of the rainy season, which varies in different parts. The artificial manure should be applied just after this. However, where cattle manure or similar slow-acting material is employed, this may well be put on earlier—*i.e.*, before the rainy season sets in; but the artificial manure, being so much more soluble, is better applied later. Cattle manure and the like may well be applied in the earlier life of the trees, and the artificial manure might be given annually from the time the plants are 3 years old."

Another firm, which has a good Eastern connection, informs me that its latest formula contains :—

9% Ammonia.
14% Available Phosphates.
15% Sulphate of Potash.

In conclusion, neither I, nor the friends who have kindly supplied me with the above data, wish to infer that the formulas are perfect, above all that they will suit all climates, soils and conditions. They are only offered as suggestions to form a basis on which to carry out experiments in the first place, for no wise planter, be the formula ever so tempting to look at, would (I take it) lay down a large area under manure without first testing it on an acre or so, to see exactly what quantity to give each tree according to age, and how the partciular mixture sent suits his trees, soil, etc.

The CHAIRMAN (Mr. P. J. BURGESS) : We must thank Mr. Hamel Smith for having introduced a very important and interesting subject to our notice. Of course, it is familiar to many of you that in Ceylon for a number of years past manuring has been adopted on rubber estates in many cases, and I do not think there can be any doubt that it has resulted in very largely increased yields. There has not been a very scientific selection in the variety of manures, and it is not reasonable so far as the planters are concerned to ask that there should be, because it is altogether out of the province of the administrator of an estate to say what should be adopted. Of course, the critical point to consider is whether the increased yield is going to pay, and that depends upon the price of rubber. It is not the fact of getting an increase of crop that proves a manure advantageous, but the question of getting a profit. This is the point very often overlooked. Experiments must, of course, be carried out to determine suitable manures ; that is not for planters themselves so much as it is for the scientific officials in each country, and these officials have to remember that the physical characteristics of soils have to be considered in all cases. It is fallacious to imagine that because a soil appears to be deficient in a certain constituent a set supply of that constituent is going to make the soil ideal. The results of manuring as carried out by a farmer have often been much better than those achieved by a scientific experimentalist. I feel that this question of manuring should be given very careful attention by the authorities of Ceylon and Malaya.

Dr. SLOCUM : Might I ask Mr. Hamel Smith what experience he has had in the use of potash in building up the caoutchouc content of latex ? It is extensively used in building up the sugar content of beet.

Mr. BURNARD : I am apparently one of the few individuals who have carried out fertilising experiments in Malaya, not in a managerial capacity. I spent three months on two estates there studying the soils as to cultivation and fertilisation. On one estate the soil consisted of sandy loam resting on laterite and the other consisted of laterite alone. Both estates had soils acid in character and somewhat deficient in lime. I started a series of experiments which I hoped would have scientific value, but unfortunately after I left, the various plots were interfered with in the process of cultivation, and as far as any scientific value is concerned it is gone. I have, however, managed to extract some practical experience and results from these experiments. I sent out five types of fertilisers, the whole being basic in character, that is to say, they were either neutral in reaction or contained a slight excess of lime. I added that owing to the acid character of the soil, the whole of the nitrogen was derived from organic sources, so as to be slow in action. The potash was, of course, from the usual sources. I fertilised altogether an area approximating to 600 acres, and the results were highly promising. Where the areas had been systematically fertilised the stem growth was remarkably good, and what I think more important still, the development of foliage has been very fine indeed. My experience out there also indicated that what these soils wanted, presuming that the estate could not afford a considerable expenditure in applying a compound fertiliser, was a simple application of lime, and my advice in that respect has been adopted with very great benefit to the whole estate. I may say the estate in question is not in bearing. I have no experience as to the results of fertilisers in the production of latex. All I wanted to see was the growth of as many healthy trees as possible, and I found that an application of 4 lbs. of good lime round each tree area—an area that might measure from 6 feet to 8 feet round the stem—made the trees respond very readily and quickly. I am convinced in my own mind, and with my very limited experience of these soils, that they are more acid than they should be, and are deficient in lime, and that the great thing is to supply lime. The great thing, if you can afford it, is to supply a fertiliser containing citric soluble phosphates, potash, and nitrogen derived from some organic source.

Dr. SLOCUM: Might I say, in regard to boggy soil such as much of the soil in Malaya and other low-lying lands in the rubber area must be, that the work of the Agricultural School of the University of Illinois, United States, has tended to prove that a large part of the good work of lime is due to the formation of insoluble lime compounds with the deleterious organic acids such as dihydroxystearic acid and the like. In the investigations of soils of rubber estates it would be well to examine the material for the presence of these bodies.

The CHAIRMAN: I do not think you can describe the soil of Malaya as in any sense boggy.

Mr. H. M. CADELL: The question is, how long is the effect of manuring of trees going to last. I applied some nitrogenous manure to some trees in Scotland, and was astonished to see the tops soon after covered with enormous growths. Next year, however, they went back. The effect of basic slag is very important. It works marvels in the promotion of growth, and this effect remains in the ground for years. That is a very important point.

Mr. BAXENDALE: I have had a good deal to do with the so-called boggy lands of Malaya. The text books tell us that peat bogs must contain at least 50 per cent. of humus. I have this morning been opportunely furnished with a letter from the Director of Agriculture in the Malay States giving an analysis of soil from an estate in which I am interested. It gives these figures of mechanical analysis:—Fine sand, 12·8 per cent.; silt, 19 per cent; fine clay, 30·4 per cent.; clay, 32·8 per cent.; humus, 5 per cent. You see it lacks by a very considerable amount the percentage that would qualify it to be called bog or peat. Now as to the chemical analysis, the letter gives these figures:—Moisture, 3·7 per cent.; organic matter, 13·7 per cent.; potash, ·400; phosphate, ·0848; lime, ·05; magnesia, ·11; nitrogen, ·25; available potash, ·023; lime absorption, 8·75 tons per acre. The Director of Agriculture goes on to say that the analyses indicate the soil to be a very rich one in all respects except in its content of lime, and that he would attribute any deficiency in growth or yield to the acidity of the soil or to inadequate drainage. The lime absorption factor, he says, is unusually high, and signifies that as much as 8¾ tons could be applied per acre without risk of any being washed through with the drainage water. It is added that the factor for an average Federated Malay States soil is three to four tons, but in the cases of other peaty coast soils figures of 5 to 7½ tons have been obtained. I may say that I have prosecuted some experiments in the manuring of rubber, but so far with negative results. I think all the scientists I have spoken to on the subject hold that it is no use manuring our soils in the Malay

Peninsula, because they are at present quite sufficiently rich in all productive respects, but cannot perhaps altogether absorb those riches of the earth because they require lime. That is also so from my own experience. In Ceylon I have had the privilege of seeing the results of Mr. Joseph Fraser's experiments, and undoubtedly the manuring has proved of very great advantage there. He is, however, using older soils. I took over a few tons of Fraser's mixture to the Malay Peninsula, and so far as it has gone it has had no effect whatever. That does not imply that in time to come it may not be of use. When we have much older soil it may be useful.

Mr. BURNARD : May I be allowed to supplement my remarks. I expect the reason in Malaya why experiments have not been successful is that lack of lime. It is no earthly use to try expensive compound fertilisers unless your soil contains lime, nor should you use under any circumstances whatever water soluble phosphates which are acid in reaction. When you have your soil in a healthy condition due to the addition of lime, you can use compound fertilisers with every confidence.

Mr. A. BRUCE : I think the reason why some of the cultivation in the Federated Malay States has not been successful is the lack of ordinary cultivation prior to intensive. In Ceylon, where manuring is highly successful, and is carried on to a great extent with all products, the soil is very free, and the drainage is very free. The soil often contains 50 per cent. of gravelly cabooky or laterite, while the soils in the Federated Malay States are finely divided peats, which have 80 to 90 per cent. of particles which pass a 0·3 millimetre sieve. These soils are close and compact and generally lack clay, settling from a cylinder of water in a few minutes. Aeration is deficient in these soils. Where ordinary cultivation has been carried on in the Federated Malay States manures have had a beneficial and paying result. Lime must in all cases be applied to soils in the Federated Malay States. The addition of 10 cwts. or more per acre prior to manuring is beneficial both from a chemical and a physical point of view. Ceylon planters, prior to manuring, have always had advice from the manure merchants from guaranteed analyses and from experience of the soil. This system is now being introduced in the Federated Malay States, and planters there will for the future have the same facilities as there are now in Ceylon. All details, such as rainfall, age, elevation, distance of planting, disease, etc., are asked for, so that the whole matter is thoroughly gone into. A well balanced manure is recommended. Specially soluble manures such as nitrate of soda and ammonia sulphate, if recommended, are in small proportion, as these are detrimental to the soil, especially in washing out the lime.

Mr. BAXENDALE : We have not been at a very great advantage in our dealings with the agents for manures, for on occasions manures have been sold to estates and afterwards the agents have said that lime should have been supplied first. That is relative to coconuts, but the same arguments apply to rubber. In the particular case that I am thinking of the agent recommended the initial application of lime about a year and a half after he had received his cheque for the manure.

Mr. R. N. LYNE : There are two points to which I would like to refer. The writer of the paper said that one of the principles of manuring was to replace in the soil the constituents which have been extracted in the tapping of the tree. I do not know what data he has for that statement. As far as I know, there are none. This point also affects that to which the chairman drew attention with regard to the analysis of soils. Both these questions are of very great importance to us in the East. I do not think we are in a position to say to what extent we can rely on the analysis of latex. There is only one way of going through with this matter, and that is by experiment and trials repeated year after year with the same soils, and with the mixtures very carefully worked out. There is another point in the paper that I would like to refer to. The writer says it is no use manuring if your rainfall is deficient. That goes into the province of the new doctrine of farming known as dry farming. One of the points brought out by Indian specialists is that manuring can to a certain extent take the place of moisture. The reason is that you get a more concentrated food drawn up into the tree by applying the manuring when your rainfall is deficient.

Mr. W. T. GIBSON: I have been struck by the relatively small amount of information we have about the behaviour of the soils and the effects of manures in the tropics. There are only two tropical products which have received any attention to speak of from these points of view, sugar cane and tobacco. Coffee has received some attention, but less than these. As far as observations have gone, it has been found that tropical soils behave quite differently from those of temperate regions. There are still, however, many problems to be gone into. It is a puzzle where the tree gets its lime; there is so little lime in the soil. I suppose the reason for our ignorance on this point is that the chemical methods of analysis do not exactly represent the chemical composition of the soil. We know that even in the temperate zone the chemical analysis are not satisfactory, and this must apply with even greater force to the tropical soils. Another point to be considered is as to the form in which the tree absorbs its nitrogen. I can find very little evidence of the formation of nitrates in the tropical soils, and I can only conclude that the nitrogen is taken in in the form of some ammonia salt. I do not think it advisable that we should adopt a general formula for manure and apply it to all soils in the tropics. We should first find out the deficiencies in particular soils.

Mr. HAMEL SMITH: I consider that the makers of fertilisers go too close to the methods of vendors of quack medicines, and claim that they cure too many diseases. The application of the one formula to meet the soil requirements of a great area is of course absurd. In Mexico, for instance, we get large pockets of land that need one treatment, and close to them other soils that have to be treated quite differently. I am sure that, although the Governments do a great deal in the way of experimenting, many estates should experiment on their own account, perhaps with help from the Government. In a place like Peradeniya, for instance, experiments can only be helpful to an extent, because you may get effects entirely different in some other part of Ceylon. I think I made it abundantly clear that I would warn planters that they must not go on analyses of crops alone. You have to build up the trees to enable them to flourish, as well as giving them any plant foods that you may have taken away. In any case, I particularly called attention to the fact that those people are wrong who merely say that the crop takes away so much plant food, therefore put it back. The tree is growing all the time, and you must nourish it for its growth. It has been proved that potash is essential for all crops for the purpose of building up the carbo-hydrates On the subject of general manuring, I would state as a matter of information that some time ago we published a book on the manuring of tea, and failed to get a sale for it in India, because the planters there declared that they were not willing to go in for manuring as they could not rely on their rainfall If you have not a reliable rainfall it certainly does discourage the use of fertilisers. Mr. Lyne knows that I am following up the question of dry farming, and I do believe manures can often be used with advantage in this connection. My idea is that manures should be supplied in liquid form, and that if your soil is well cultivated, you could, in some cases by the use of the drill, go a little below the surface and then treat the top of the land to prevent evaporation. In spite of all the importance I attach to manuring as a principle, and no one denies its importance, I say that the first thing everyone has to find out is that he gets the right kind of manure. That is the reason I had for reading this paper to-day. I am not an authority on the subject, but a large number of men have asked me where they could go for information. The point I wish to make is that he who looks after himself gets the best attention, and this applies to manuring, I think more than to anything else.

The Rubber Plantations of Angola.

By

Professor C. de MELLO GERALDES.

Dr. Schidrowitz presided during the reading of this paper, which was as follows :—

During the last few years, especially since 1911, the year in which the manufacture of brandy was prohibited in Angola, the cultivation of the rubber tree has greatly developed in that colony, and especially in the northern districts (the Congo, Loanda and Lunda). In 1913, according to statistics, the plantations in Angola comprised about 3,500,000 rubber trees. In reality, however, the number of rubber trees cultivated on the Angola plantations was much greater, as the statistics which we have consulted on the point were anything but complete, several plantations having been omitted.

If one takes into consideration what is as yet hardly permissible to hope, that rubber may once more attain the high prices it formerly commanded, then, with the agriculturists continuing to plant rubber trees, and particularly the *Manihot Glaziovii*, with the Department of Agriculture and the experimental stations distributing gratis large quantities of rubber seed, and also with the Government, through the Colonial Ministry, making every effort to encourage the industry, it is fair to suppose that within a very few years the vast Colony of Angola will become an important centre of rubber production.

It is only to be regretted that the establishment of these large rubber plantations was not begun earlier; but this was due to the fact that before the manufacture of brandy was prohibited the colonists devoted themselves exclusively to the cultivation of the sugar cane and sweet potato for distilling purposes, and carried on a barter trade with the natives for rubber principally prepared by them from the rubber weed. Another reason for the rubber plantations of Angola having failed to develop until within the last few years is the indifferent result obtained by the agriculturists who made the first experiments in the cultivation of the *Manihot Glaziovii* in the Colony. This was due to their not having employed selected seed, and above all because they were not at first acquainted with a practical method of tapping the rubber trees. As is well known, the individual specimens of the *Manihot Glaziovii* species vary greatly, not only as regards the quantity of latex yielded, but also in the yield of rubber from the latex. As a matter of fact there exist trees the latex of which contains no rubber at all, as has been proved by the researches of Messrs. A. Cardoso and (1) W. Johnson in the plantations of Mozambique, as well as by other experts.

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(1) A. Cardoso : "Manicoba in the Province of Manicoba," in "Relatorios e Informacoes," 1908. Lourenco Marques, page 11. W. Johnson : "The Rubber Industries in the Territories of Manica and Sofala," page 19. Bulletin of the Imperial Institute, Vol. V., page 601, and Vol. VI., No. 3, page 255.

At the present time the planters in Angola attach the greatest importance to the selection of the *Manihot* trees, and employ the method of tapping by means of punctures, which is the best method known up to the present for extracting the milk from the rubber tree. The *Manihot Glaziovii* is at present cultivated almost exclusively, but experiments have also been made with the *Manihot dichotoma, Piauhyensis, Hevea brasiliensis, Ficus elastica, Castilloa elastica,* and *Funtumia elastica.* It seems that it is the present practice on almost all the rubber plantations to remove the outer bark before tapping *Manihot Glaziovii.* There are planters, however, who do not adopt this system because they think it wasteful and because sometimes the trees die after it. In this connection, as I have had occasion to mention in a previous report (2), Monsieur Silva Neves, a *Manihot* planter in Angola, is of opinion that the barking of the *Manihot,* besides being a costly operation, is fatal to some trees, in the proportion of not less than 15 per cent. In view of the fact, however, that the majority of the *Manihot* planters in Angola adopt the method of removing the bark before tapping, it seems that one must come to the conclusion that the operation is

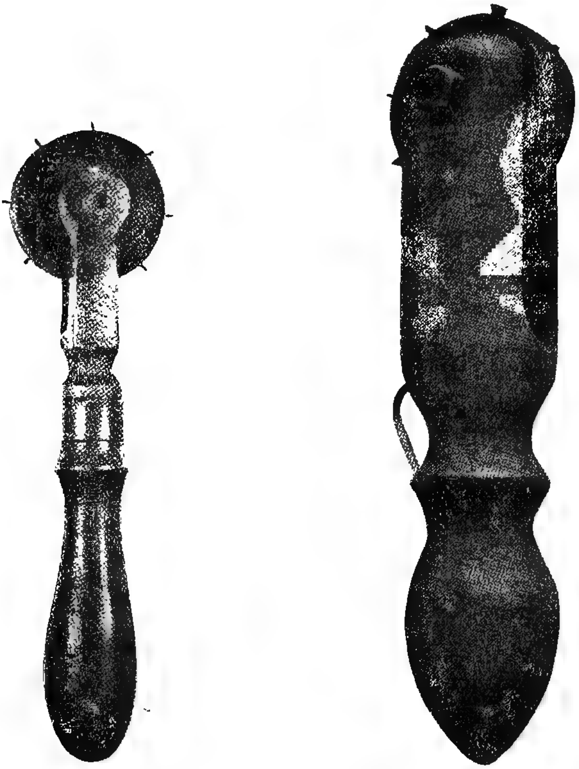

Fig. 1 et 2 — Inciseurs «Santos»

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(2) C. de Mello Geraldes: "Rubber in the Portuguese Colonies." Lisbon, 1910. Page 62.

advantageous if carried out with care to occasion the least possible damage to the trees, and if the incisions are also made with every possible precaution to avoid penetrating the cambium. The process of barking is now generally practised in all countries which cultivate *Manihot Glaziovii*.

In tapping *Manihot Glaziovii* it is usual to first remove the bark from the trunk to a height of about two metres, and then to make a vertical series of small horizontal incisions by means of a sort of "pricker," beginning at the base of the trunk and going up as high as the arms of the workman can reach. The instrument usually employed is the "Santos incisor," invented by Monsieur Santos, a planter of Angola. Tapping is carried out from 5 to 10 o'clock in the morning, during the rainy season (3), and the latex is made to flow into cups placed at the base of the trunk. This latex is then emptied from the cups into buckets and carried to the factory where the rubber is prepared. In the usual way of preparing the rubber, the latex is poured into trays made of wood or enamelled iron, then mixed with water and kept in this state for 5 to 24 hours, which is sufficient time to ensure spontaneous coagulation. On some plantations the rubber is washed, and in others it is smoked during the drying process, by burning the refuse of the oil palm nuts in the dryer.

On the plantation of "Rio Zenga," one of the most important, the average yield of the *Manihot Glaziovii* per year and per tree is as follows :

AGE OF TREE.	YIELD OF RUBBER.
5 years	250 grammes.
6 ,, ...	300 ,,
7 ,, ...	400 ,,
8 ,, ...	500 ,,
9 ,, ...	600 ,,
10 ,, ...	700 ,,

As regards this same plantation, the cost of production and expenses of export to Lisbon, per kilo., are as follows :—

Tapping and preparation of the rubber	Frs. 2.20 per kilo.
Transport to Lisbon	,, 0.38 ,,
Duty, Insurance, Commissions, etc.	,, 0.50 ,,
Total	,, 3.08 ,,

On the Conceicao Pinto plantation, the cost of production, extraction of latex, and preparation of the rubber is as follows :—

Collection of latex, at most three half-days at the rate of fr. 1.10 per day	Frs. 1.65 per kilo.
Preparation of the rubber and superintendence of the natives by a white	,, 0.80 ,,
Total	,, 2.45 ,,

The majority of the trees being very young, the production of plantation rubber in Angola is very limited as yet, a reason for the fact that so far they have no clearly defined commercial types of rubber. The plantation rubber is at present exported in the form of sheets of different shapes (generally, however, rectangular) and of varying thickness, usually between 2 and 5 millimetres, and the scrap in lumps, balls or leaves of various sizes.

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(3) During the rainy season in Angola it is usually only in the afternoon and evening that rain falls.

In the Colonial Agricultural Museum of the Higher Institute of Agronomy in Lisbon there is an important collection of samples of plantation rubber of the *Manihot Glaziovii* from Angola. The first samples (in sheet form) which we received were obtained at prices fluctuating between frs. 2.50 and 10.50 per kilo. The price of fine hard Para from the Upper Amazon was then frs. 10.90 the kilo. We have recently received other samples of plantation rubber in leaf form and scrap. The sheets were bought at prices between frs. 5.25 and 5.65 per kilo., and the scrap was frs. 4.75 per kilo. The market price of fine pale crepe was therefore 6.35 frs. per kilo. It will therefore be seen that the rubber produced on the Angola plantations is already sold at a price approaching that of the best plantation rubber of the East.

At the International Rubber and Tropical Products Exhibition, opened a few days ago, it is possible to see a very complete collection of plantation rubber from Angola in the section devoted to the products of that Colony.

The CHAIRMAN: It is of great interest to hear that ordinary methods of coagulation are applicable to *Manihot Glaziovii* in Angola. In many districts where *Manihot* is cultivated the latex cannot be collected, but is permitted to dry on the tree. It appears that in Angola they can collect the latex quite early in the day, before 10 o'clock in the morning. They allow the latex either to coagulate spontaneously or by the addition of a little water. They do not use any acid. I think we have had a very interesting paper. We hear so much about *Hevea* nowadays that we are apt to forget that there are other rubbers.

Rubber Cultivation in Cochin China.

By

ANDRÉ CREMAZY.

(*Ex-President of the Chamber of Agriculture of Cochin China.*)

In 1911, during the last Rubber Exhibition, which like the present one, was directed and managed by the indefatigable Mr. Manders, who has brought to the organisation of these international functions all the resources of his methodical mind, I had the honour of giving a lecture in the Agricultural Hall, on the subject of " India Rubber in Indo China," which lecture was subsequently printed in " The Rubber Industry."

It is a new honour for me to come before you to-day, and it is also a great satisfaction ; one that I share with all the representatives of the rubber world—to declare, in rapidly surveying the past, how much the last Exhibition in London did for the cause of rubber. Let us hope that from this year's Exhibition we may gain information very much needed by us all, at this crisis which has been brought about by the fall in price of rubber.

As regards Cochin-China, about which I am going to speak to you yet once more, at the risk of repetition, you know what its circumstances are. It is pre-eminently an agricultural country, and is the richest of all the divisions of the Indo-Chinese Union. Rice, of which more than 1,200,000 tons is exported annually, has enriched both the native cultivator and the European exporter. There has then been no occasion to seek other sources of wealth ; there were, however, large areas of elevated tracts which had remained uncultivated, and the success of an unassuming colonist, Mr. Belland, who, with a few thousand trees, made handsome profits, led us to plant *Hevea brasiliensis* on these lands. The opening of the Trans-Indo-Chinese Railway, crossing this area from Saigon to Phantiet (China Sea) and the boom which came just at that time, contributed greatly to this development in agriculture.

During the last three years the cultivation of rubber has greatly developed ; we have now nearly 20,000 hectares in *Hevea brasiliensis*, comprising more than 4,000,000 trees. Four companies have started rubber production : La Societé Agricole de Suzannah, la Societé des Hévéas de Xa Trach, la Societé des Hévéas de Tan Thank Long, and the Belland Estate, all of which have profited by the experience of the last-named. So far, not much rubber has been exported, but in about five or six years, when all our trees will be on an average ten years old, it is not rash to say that we shall be in a position to export from eight to ten thousand tons, that is to say, a quantity abundantly sufficient for the needs of France and of her Colonies.

Naturally these results cannot be compared with those obtained in the Malay Peninsula, in Java and in Sumatra, where plantations were begun twenty years ago; but they are very good if we remember that there is little money from the metropolis and that our plantations and companies have been created and formed chiefly through local resources, thanks to the thrift of the colonist and of the French official. These particulars explain why it is that there are few large companies in Cochin-China. It is the country of the small planter, either official or colonist, alone or in partnership, who has devoted his savings to this culture, on 80 estates. There are about fifteen limited liability companies. We must, however, notice an influx of capital from the metropolis and from Europe which seems to be on the increase. Belgian capitalists have formed two plantations in the province of Thudaumot at the instigation of Mr. Hallet, the well-known planter, who had previously chosen the land now occupied by the Indo-China-Rubber Company to the formation of which he himself had contributed. We hope that this movement of capital will continue. There are in Cochin-China, it is true, some very large fortunes, and the natives are very well off, but they are in the habit of loaning their money on the rice-crops, and on the security of the rice fields. The Government realized that the companies and planters needed money to tide them over without difficulty until the time for the returns to come in, they having for the most part started with insufficient capital, and, therefore, made arrangements with the Bank of Indo-China to grant loans to them on mortgage, on the security of the Colony of Cochin-China. These loans on mortgage are made for ten years, and the repayments begin by equal annual payments at the end of the third year. In this way all menace of disastrous liquidations is averted.

Our planters, while not fearing the fall in the price of rubber, owing to the low cost of production, have wished, nevertheless, to secure themselves against this fall in price by utilizing the uncultivated part of their property for other crops, such as coconut palms, coffee and cotton. I have shown in lectures and in previous pamphlets that we need envy no other country as to the yield of our coconut palm, and the quality of the dry product; the following analysis gives us all the necessary information:

	Lepine (1) Kilos.	Bachoffen (2) Kilos.	Rideau (3) Kilos.	Cay Dua (4) Kilos.
Coir Fibre	0·625	1·225	0·850	0·934
Shell	0·141	0·247	0·238	0·285
Kernel	0·434	0·396	0·320	0·496
Water	0·250	0·268	0·332	0·736
Totals	1·450	2·136	1·740	2·451

In the Gulf of Siam, on the plantation of the Phu-quoc Island Development Company, the yield of the coconut palm exceeds all expectations. This company, together with the Anloc Company in the Bien-Hoa province, have more than five hundred hectares planted with coconut palms. The coffee plant has also appealed to rubber planters as a useful incidental product ; *Robusta*, a vigorous species which bears in the second year, is preferred by planters, who are attracted by the results obtained in Java and in Sumatra in the cultivation of this species. Special mention is due to a new crop, namely, cotton. This plant was already grown in the gardens of the natives. M. Trigant, a colonist, noticing its fine growth and its yield, recommended growing it on a large scale. The samples of the product sent to various Chambers of Commerce in France were found to be of excellent quality, and this decided many planters to follow M. Trigant's example. It is a perennial species, probably of American origin, long since acclimatized in its new habitat, and has acquired such peculiarities that botanists are divided as to its characteristics. It is not yet known whether to class it as *Barbadense* (or *Gossypium religiosum*) of Linnés, or as *Peruvianum* of Earth. Some French botanists say it has some analogy with the hard Peruvians (Perous durs). It is planted at the beginning of the rainy season, during which it attains sufficient development to flower in the dry season, so that the crop is gathered under excellent conditions of yield. In the rainy season of the following year it is pruned, so that it may yield a new crop in the second dry season, and so on. It is asserted that some of these shrubs that are nearly ten years old have gone on producing a perennial growth. This, then, is a crop which is expected to counterbalance largely the effect of the fall in the price of rubber.

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(1) Malay Peninsula.
(2) Ceylon.
(3) Annam.
(4) Island of Phu-quoc, provinces of Mytho and Ben-Tre (Cochin-China).

Having said this on the subject of accessory crops, you will allow me to take up once more my principal subject, the cultivation of rubber. You know from what has been previously said that in Cochin-China there were two well-defined kinds of lands, the grey lands and the red lands, the latter forming a wide belt of about 400,000 hectares from the sea inland, crossing the provinces of Baria, Bien-Hoa, and Thudaumot, disappearing finally in Cambodgia. These lands are of volcanic origin, and reach 175 metres in altitude. The soil is very rich in nitrogen and phosphoric acid, very deep and very porous ; they keep very cool in all seasons and very moist, and this suits *Hevea brasiliensis*. The grey lands, although they do not appear to be so rich, have, nevertheless, also given remarkable results. Mr. Belland, who started the first rubber plantation about which I have already spoken to you, planted in the grey lands.

These grey and red lands, which are suited to the culture of *Hevea brasiliensis*, are situated in the east and north-east portions of Cochin-China. The rubber tree grows also in Cambodgia, in the province of Kampot, and in Annam, but does not go beyond the latitude of Qui Nhon.

I have already drawn your attention to the season called the dry season, which begins at the end of November and finishes at the end of April, and about which much has been written. An objection we have long been accustomed to hear is—" your dry season, we are told, is a serious drawback to the growth of our trees." In the first place, the results obtained speak for themselves and contradict this statement. Moreover, it should be remembered that during the six preceding months from May to November, the rain falls in torrents, so that in the end the average rainfall for the whole year is 2 m. 276 cm., plainly equal to the average of the neighbouring countries reputed to be rubber producers, viz., Ceylon, 2 m. 514 cm. ; Singapore, 2 m. 385 cm. ; Malacca, 2 m. 136 c.m. ; Penang, 2 m. 623 cm. ; Java, 2 m. 584 cm. ; Sumatra, 2 m. 254 cm.; Borneo, 2 m. 41 cm.* We have the advantage of having the rain in the afternoon, therefore tapping operations are not interfered with, and the latex is not diluted by rain water. Some planters have declared that the growth of *Hevea* is greater in the dry season, and that the average yield of rubber was higher in November, December and January than during the months of the rainy season. At all events, in spite of the dry season, it has been possible to show annual increases in circumferences ranging from 0 m. 10 cm. to 0 m. 18 cm.† Finally, this dry season, so much objected to, has one effect unexpected by these detractors—it gives us healthy trees and shelters them from the diseases that make such ravages in the Malay Peninsula. We are not troubled with *diplodia rapax* nor *fomes semitostus*. As a matter of fact, the Government of Cochin-China, fearing the possibility of contagion coming from our neighbours, has forbidden the introduction of rubber plants from the Malay Peninsula. This information, given by me at the last London Exhibition in 1911, impressed Dr. Torrey, the President of the Congress, and he acknowledged that the climatic conditions were very remarkable. On the other hand, it is well to point out that the hygrometric conditions in Cochin-China are obviously equal to those in Malaysia, and that the fall in temperature during certain nights causes heavy dews that give to the soil an appreciable amount of moisture.‡

The growth of our trees during the first years is not quite so rapid as in Malaysia. In the highlands they begin really to grow after three years, and make up for this delay by those remarkable increases mentioned above, so that trees seven or eight years old have the same height and the same circumference as those of the same age in neighbouring countries. Here are a few measurements made by Mr. Harrington, a foreign planter, sent on a mission to Cochin-China by European capitalists:

Société des Hévéas de Xa Trach:
  Trees two-and-a-half years old measured 0 m. 203 cm.

Société Agricole de Suzannah:
  Trees three years old measured 0 m. 305 cm.
  Trees four years old measured 0 m. 457 cm. to 0 m. 457 cm.§

As to the method of planting, I have to make the same remarks as at the Exhibition of 1911. We prepare our land in the dry season so as to plant in the height of the rainy season without going beyond September 15th. We plant at a distance of 4½ metres to 5 metres in guincunx, or at 6 square metres. A few planters have increased the distance between the trees, and following the recommendations of Mr. Wickham, the Father of *Hevea* planting, are planting at a distance of 10 metres. The nurseries are prepared in the dry season, the seeds come either from the Belland estate, which used to get its seeds from Ceylon, or from Singapore. Many planters recommend planting the germinating seeds at once in prepared holes. It has, in fact, been stated that with this system of direct planting the young trees do not suffer, and grow rapidly.

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* O. Dupuy. Comparative Study on the cultivation of *Hevea brasiliensis* in Cochin China compared with that in the various countries of the Middle East, page 13.

† Journal of Tropical Agriculture, 30th April, 1914, page 98.

‡ Bulletin of the Annals of Indo-China Rubber Planters at the Ghent Exhibition, 1913, page 14.

§ Octave Dupuy, page 22.

Ploughing by steam is practised on the large scale on a number of plantations, such as Xa Trach, Suzannah, Xuan Loc, Courtenay and Tan Thuy Ha. Tillage is the best safeguard against *tranh* (lalang), which is so destructive. On the " Caoutchoucs de l'Indochine " plantation, clean weeding is successfully practised. On the grey lands where lalang is rare, and where the soil is light, ploughing with oxen is practised to improve it. Keeping in good state of cultivation is simple and inexpensive ; I remember accompanying a Director from the Malay Peninsula over a plantation of about 30,000 trees distributed over about 100 hectares. He asked the manager how many coolies he had, and he replied " ten " they could moreover, be seen driving five ox-ploughs. He said that these ten were sufficient for the ploughing, but that during one month of the year he engaged fifty to spread manure around the trees. This surprised the Director who thought the plantation very prosperous and very well managed. In the red lands, the soil being heavier and deeper, the steam-plough is necessary, and secures such a yield that it is more economical than the ox-plough. In land already planted, where many precautions must be taken not to spoil the trees, a steam-plough does on an average four hectares a day in both directions at a cost of 16 to 20 piastres ; while an ox-driven plough does one hectare in both directions in one week, at a cost of from 8 to 10 piastres per hectare.

With reference to tapping, we have naturally been led to adopt the method of the Malay Peninsula, using certain modifications necessitated by the difference of climate. At the Government Station of Ong Yem, after having tapped on the spiral system, the half herring-bone, and the V system, the half herring-bone system has been adopted. Many planters use it, tapping only the fifth part of the trunk. The bark has thus a longer time for renewing itself, and this decrease in surface affects in no way the yield of latex. The number of trees a coolie can tap in one day varies between 300 and 400. One planter, however, says that on the estate he is managing, by omitting certain useless operations such as the watering the little collecting channel, his coolie men can tap 600 trees and his coolie women 450.* Inquiries having been made at the offices of the Suzannah Agricultural Company, 58, rue de Chateaudun, Paris, these statements, which at first sight might cause surprise, are corroborated by the books of the company. Results such as these are a record, and in this time of low rubber prices, one is glad to have recourse to every means of economizing. It is worth remembering that the same coolie makes two incisions on 600 trees, collects the latex, cleanses the cups, carries the latex and the water for washing to the factory, and washes all the utensils used, the whole being done between 5.30 a.m. and 11.30 a.m. These are valuable examples for young plantations that have not yet reached the tapping stage. The native of Annam is very skilful ; he has a well-knit frame, and a supple hand ; for him tapping is easy work and he excels in it. Tapping is stopped during the months of February and March, when the trees lose their leaves.

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* Journal of Tropical Agriculture, 30th April, 1914, page 99.

We possess also reliable information on the yield per tree. For the last three years our trees have prospered at Ong Yem (Government Plantations) and the Belland Plantation there are trees ten and twelve years old; the yield is from 2 k. 400 grm. of dry product per tree. M. Belland, in 1913, exported 24 tons as the result of tapping 10,000 trees. In plantations with trees seven years old the stated yield is one kilo. per tree.

As to the quality of the product, it leaves nothing to be desired. Belland rubber, Suzannah Agricultural Company, Xa Trach, Hevea Company, and Ong Yem, have been sold at first latex prices. On consulting the analysis of Ong Yem rubber, which Mr. Manders kindly obtained in London in 1911, this being the only Cochin-China rubber exhibited at the last Exhibition) I see that the vulcanization process has been successful.* At the Ghent Exhibition (1913) the "Société Agricole de Suzannah," the "Station Agricole de Ong Yem," la "Société des Hévéas de Xa Trach," and "Belland" estate rubbers carried off the Grand Prix.

I have mentioned that hand labour was relatively easy to obtain. Certainly a very large number of coolies must have been employed to put twenty thousand hectares under cultivation. The hand labour is local, and is easily recruited if your plantation is situated near the markets and near the centres of population. You get it offered you if you are near a railway line or if access to your plantation is easy. Hand labour comes also from Annam, from Tonquin and from Java. The day's pay of a coolie man varies from three-tenths to four-tenths of a piastre; of a coolie woman from two-tenths to three-tenths of a piastre, according to the situation of the estate. In addition to this, 800 grammes of rice must be given each man, and 600 grammes to each woman. The piastre is worth from 2 francs 20 centimes to 2 francs 50 centimes. Local regulations allow the judges to order the arrest of the coolies who desert on the expiration of their punishment and to bring them back under escort to the plantations where they were employed.

The colonist obtains his lands through a grant, and may buy them by private contract after a vote of approval in the Colonial Council, or he can acquire them at the public sales by auction with the formal concurrence of the Government in Privy Council. The applicant must first of all deposit a warranty of not more than one piastre per hectare, this being returned to him if the concession is granted when one-tenth of the land conceded has been cultivated. In the case of sale, the deposit is deducted from the price. The cost of land has varied from half a piastre to 5 piastres per hectare. To be recognized as the lawful proprietor of the acquired lands, the rubber planter must each year, if his plantation contains 500 hectares or less, plant the tenth part of his land, so that half of the land may be under cultivation at the end of five years. If he has over 500 hectares, he must plant the twentieth part, so that half may be under cultivation at the end of ten years. As to the remainder of his land, the proprietor is at liberty to let it lie fallow, to turn it into pasture, or to devote it into other crops, the essential condition being that half its surface be planted with rubber. The planter may, however, apply himself to crops other than rubber by obtaining the permission of the Government in Privy Council. The tax to be paid is that levied upon the first division of the various crops—namely,

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* Letter of Mr. Manders, 22nd November, 1911.

$2.75 per hectare; but it is only imposed the seventh year after the sale or the grant, and on the tenth part of the whole area of the land; this tax increases one-sixth each succeeding year up to the tenth year. In the tenth year the tax is due on the whole area of the rubber plantation; that is to say, on half the transferred land. The other half of the property, after the seventh year, comes wholly under the general tax appertaining to various crops, namely, $0.48 the hectare, deduction being made of an area equal to the tenth part of the whole property to be exempted from taxes.

All these conditions are eminently favourable to the colonists, the relatively very low cost of hand-labour, the very advantageous purchase price of land, freedom from taxes during six years, payment of the highest tax on only one-half of the land in the tenth year, and excellent yield of the trees. All this allows the planter to produce at a very good profit. The oldest plantation, that of Mr. Belland, produces at the rate of Fr. 2.50 per kilo. The President of the Board of Directors of the "Société Agricole de Suzannah" has assured me that he now produced at 3 francs per kilo., and that he hopes soon to produce at a still lower cost. The cost of bringing one hectare of *Hevea* plantation to the tapping stage, depends upon the situation of the land, and upon its configuration. On the grey lands, where there are no forests, the cost is so low as to be at first sight surprising. There are some lands that can be capitalized at 750 frs. the hectare.

Our colonists may, therefore, contemplate the future with serenity; they have confidence that the fall in price of rubber cannot affect them, for a fall below 5 francs is not to be anticipated. Relying on this price, they have all made their plans.

But how is it then that there are still more than 350,000 hectares of red lands uncultivated, suited as they are to the cultivation of coffee, coconut palms, cotton, sugar cane, camphor, etc.? It is because Cochin-China is still little known, except as a country that produces rice; it is because it is in need of money from the metropolis; and finally, because the nature of the native is to desire no knowledge of any other crop than his rice and the loans on the rice crops. The French are under the influence of the Parisian Banks, which have placed upon the French markets shares of foreign colonial companies at quotations far above par. The present fall in prices should certainly set French capitalists thinking over the by no means brilliant transactions they have had forced upon them. As to the local Banks, they have not yet found an opportunity for informing French capitalists that they had profitable investments for their capital in agriculture in Cochin-China. They are satisfied with drawing enormous profits from discount and exchange; they have not felt called upon to contribute to the formation of local companies and altogether refuse to promote the interests of agriculture.

Exhibitions like the International Rubber and Tropical Products Exhibition in London, and those held at Ghent and Lyons, at which our rubber and other products have been honourably represented, are the happy means of drawing the attention of capitalists to the unsurpassed wealth of this magnificent country.

Extract from the Annals of the Rubber Planters of Indo-China, No. 36, *February,* 1914.

MONSIEUR GUERY'S METHOD OF COAGULATING COCHIN-CHINESE RUBBER BY SMOKE.

The President presents to the Committee a sample of rubber coagulated solely by smoke, according to the Brazilian method, put in practice by M. Guery, the founder and technical director of the Hevea Planters of Tan-Thanh-Dong. As far as he knows this is the first sample of this species so treated in Cochin-China. The ease and cheapness of the treatment make it of great interest, as it does away with the necessity for machinery, and is easily effected. The smaller planters of Cochin-China would certainly derive considerable benefit from this system, from the point of view of economy of manufacture as well as from that of quality of the product.

The following are particulars of the method in question, as carried out by M. Guery :—The coolie comes back from the plantation carrying his harvest of diluted rubber. He pours it into a pan, and places himself near his stove. This stove is made with an old petrol heater, one end of which has been taken out (that which is turned upwards). At one side of the heater, and in the bottom, there is a small opening to permit of the stoking of the fire, which is made up of shavings, sticks of wood and paddy husks. Very soon a thick smoke comes from this apparatus. The coolie puts into the smoke a cylindrical bamboo cane about 50 centimetres long and 20 millimetres in diameter, which he rolls between his fingers in such a way as to heat it and impregnate the end of it with smoke. After a few minutes he takes his bamboo out of the smoke and dips it in the pan of latex, turning it in the same. Two phenomena are at once produced : particles of pyrolignous matter are condensed and fall from the bamboo into the pan, and a little—a very little—rubber is coagulated round about the head of the bamboo stick. This stick is again put into the smoke, and then, when it is again covered with pyrolignous matter it is once more plunged into the pan. The same phenomena occur, *viz.*, the dropping of the pyrolignous matter which spreads in the pan, and the fixation of a small quantity of rubber on the bamboo. The same process is repeated over and over again for about half an hour, during which time the contents of the pan become charged with pyrolignous coagulating matter, and the end of the bamboo becomes coated with layer after layer of coagulated latex. Towards the end of the operation one can see the latex gradually rise to the surface of the pan, first of all in the form of small clots, which little by little collect together, finally forming on the surface a pellicule of coagulated rubber which the coolie plasters on to the small pear already formed at the end of his bamboo, pressing it on as firmly as possible with his left hand, and then placing the whole for the last time in the smoke of his stove.

Five hundred grammes of rubber coagulated in the smoke may thus be prepared by the coolie who milks the tree, who, as soon as the pear of rubber is ready, can easily pull it off his bamboo. There is nothing left to do but to dry it in the open air or else in a drying room. M. Guery finishes the operation by pressing the pear of rubber in a small hand-driven toothed roller which he has, so as to denude it of part of the water it contains. The pear then takes the form of a flat oval. This rubber has been sold at Hamburg for six marks per kilo.

The reading of this paper was supplemented by a series of vividly interesting cinematograph films.

M. Cremazy, in answer to the Chairman (Dr. Torrey) stated that it would take a coolie only about an hour to make about 500 grammes of dry rubber by the process he had described.

The Chairman : What is the extent of the Company's planting ?

M. Cremazy : It is a new company with about 200,000 trees five or six years old. The manager has preferred to use the Brazilian process in the first place, and has succeeded.

The Chairman : How much rubber has been sold ?

M. Cremazy : I do not know, but the export this year will be about 10 tons.

Kelantan as a Rubber Producer.

By

T. CLIFTON HUTCHINGS.

(*Chairman, Kelantan Planters' Association*).

One of the least known States in the Malay Peninsula is Kelantan, a country having an area of about 5,000 square miles, with a long coast line on the eastern side, and within forty hours by sea from Singapore.

A regular steamer service is maintained between Singapore and Bangkok, and practically daily communication is kept up in this manner.

The State was acquired from the Siamese Government by the British in 1909, and although not yet one of the Federated Malay States, the Administration is carried out by the Federated Malay States Civil Service, and laws are made and passed by His Highness the Sultan of Kelantan in Council with a Resident British Adviser.

With respect to population, Kelantan is much better off than neighbouring States, as it has about 300,000 people, of whom 287,000 are Malays. This population is greater than that of the Straits Settlements or any other State in the Malay Peninsula.

As in most undeveloped tropical countries, the means of transport until quite recently have been confined to waterways, the country being intersected by rivers navigable by native boats, while the main rivers are deep enough to allow steam and motor launches to penetrate more than 100 miles into the interior.

Under the British regime the development of the State has been extremely rapid, and the Federated Malay States Railway Department has already constructed a line, 40 miles being now open to traffic, while the extension of this means of communication now that the route is finally decided upon, will advance with rapid strides, so that in a year or two it will be linked up with the main line of railway between Singapore and Bangkok, as well as with the neighbouring and more developed States. Finances have, so far, been in too low a condition to allow all necessary improvements, but the Kelantan Government, supported by the European and Malay population, has approached the Federated Malay States Government with a view to being taken into the Federation at an early date. If this takes place, development will continue at a more rapid rate, and one of the most fertile tracts in Malaya will be added to the Federation.

From an agricultural point of view Kelantan is unequalled in the Malay Peninsula. The great fertility of its soil, the plentiful annual rainfall, and its naturally well-watered and well-drained areas, combine to produce such a rapid and luxurious growth of vegetation as to cause surprise to every visitor to the country.

The staple native industries are: rice and coconut cultivation, cattle breeding, fishing, and silk weaving.

Until a few years ago, the collection of indigenous rubber attracted a number of Sarawak Dyaks to Kelantan, and a large export of wild rubber took place annually, but owing to the wanton destruction of the trees during the extraction of the latex, the output is now exceedingly small; and that of the highest quality, Getah Taban, has absolutely ceased under a prohibition of export until better and less destructive methods of collection are adopted.

Since 1907 the most notable feature of the country has been the development of the Parà rubber plantations, and a total area now under European management approximates 20,000 acres planted, of which about 3,000 acres is already bearing and producing rubber of as high a standard as any shipped to the London market.

There are fourteen companies, controlling as many as 23 different estates, and when the demand for rubber and the state of the market warrant it, all have excellent land for extension.

The reports of many well known rubber experts who have made a special point of investigating the possibilities of this industry, tend to prove that Kelantan ranks absolutely in the first line of rubber-producing areas, the growth of Parà rubber trees there being unequalled. Such reports as these are to be expected, for practically all the estates have planted in virgin soil, planters having preferred to fell and clear the jungle rather than use an impoverished soil that has borne exhaustive crops of tapioca, padi, and other native produce for many years past, or areas that have been abandoned by native cultivators and grown up in lallang.

Compared with other Eastern rubber-producing countries, the growth in Kelantan is perhaps superior, but the question of cheap and efficient labour still leaves something to be desired, and combined action by the Government and the planters is necessary to induce an influx of cheap and efficient labour. Even if the Government is put to expense for a few years in arranging a scheme to populate the State with imported labourers (the local Malays, although very numerous being too idle to work regularly on plantations after the first task of felling and clearing is accomplished) it will in later years reap the benefit in revenue on exports, and the prosperity of the State will be greatly enhanced. Until quite recently the importation of Indian labour was prohibited, but this restriction now having been removed, the popularity of Kelantan has still to be established, and more help from the Indian Emigration Department would tend to place the State on the same labour basis as competing districts.

Much may be said regarding indentured Chinese labour. In response to a petition from the Kelantan Planters' Association and His Excellency the Governor of the Straits Settlements, special facilities have been granted for the use of Chinese labour, and two years extension has been added to the limit when indentured Chinese labour may be imported. This materially helps planters with the labour question, and it is hoped that in the near future Kelantan will be the most popular State with coolie immigrants, seeing that estate managers there are prepared to allocate small holdings of land on their respective estates for permanent settlement of the families of coolies working on the estate, in cases where they do not care to live in the usual coolie lines.

On completion of the railway system, which is now being rapidly pushed on, practically every estate will have railway facilities either on the properties or within a very short distance. By these facilities of transport Kelantan will be placed on an equal footing with other States.

Considering the recent opening up of jungle areas, the health conditions are fairly good, both as regards Europeans and Asiatics. Every effort is being made by the Government and estate managers to have proper hospital accommodation provided for Europeans. Asiatics are already well provided for in this respect. It is hoped that in the near future the Government Treasury will be in a position to make ample provision for the welfare of Europeans.

During the last four years vast areas have been planted with coconuts, and the growth on the newly-planted areas, about 7,000 acres, is considered most satisfactory. The properties leased to various companies are approximately 22,000 acres, and older plantations owned by native holders have a producing area of about 8,000 acres showing excellent results. The first prize at the Singapore Exhibition, 1910, was taken by a Kelantan exhibit of coconuts, the size of the nuts, the exceptional thickness of the kernel and the high percentage of oil being taken into account. The latest returns published show an export of 70,000 coconuts, 80,000 pickuls of copra, and a small quantity of coconut oil.

With regard to mineral wealth, there are splendid indications throughout the State, but transport difficulties in the past have prevented proper development. With the advent of the railway system it is probable that the mineral production of this State will be exploited on a large and profitable scale.

A large quantity of alluvial gold has already been recovered by dredging in the rivers, and a small export of tin has been made and satisfactory prices obtained.

In conclusion, this brief report will, it is hoped, give some idea of the position that Kelantan already occupies in the rubber world. The country should prove one of the most valuable additions to the British Empire.

Cultivation of Rubber-growing Vines in Central Africa.

BY

E. DE WILDEMAN

(*Jardin Botanique de l'Etat, Brussels.*)

Dr. Torrey presided.

The CHAIRMAN: Before reading extracts from the next paper, which is by Dr. de Wildeman, I would say that in all this Congress so far there has been such a difference in the papers and discussions as contrasted with those at previous gatherings that it is hardly possible to get those who were not present on the previous occasions to appreciate the manner in which the conferences differed from this one. I have asked some of those who were present at the last Congress whether they have not noticed the great difference between our work now and that we had before us then. The first paper of the last Congress was one the discussion of which led to one of the most active and acute discussions I have ever heard on any paper, and at the end of the time the whole Conference practically demanded that more time should be given for the discussion, with the result that on the next day an extra two hours had to be assigned to it. What do you think the subject was? Well, it was the forest growth of *Funtumia elastica*. If the first paper at this Congress had opened on that subject it would have cleared the room in twenty minutes. That was three years ago, and I mention the incident just to show how enormously things have moved on. This paper, the only one on any such subject that we have at this Congress, impresses me as an extraordinary instance of the persistency of a man's convictions. Therefore, with your permission, as Dr. de Wildeman is not here, I am going to take the opportunity of reading some extracts from his paper. It has some strong points in connection with it. Most of us can see very little interest in the subject just now, but one does not know when it might be of interest.

The paper, as follows, was then presented to the Congress.

In 1911, on the occasion of the second International Rubber Congress held in London, I urged the importance of continuing to cultivate and to exploit the native species of rubber-bearing vines in Africa. In the "Official Guide Book" I closed my account of "Native or Exotic Rubber Trees" by emphasizing the necessity of each country having its natural products as well as its producers well suited to the locality.

At one of the meetings held in the Exhibition Hall I further discussed the subject of vine rubber in detail, and gave as my view, that the best method of dealing with the management and the cultivation of Congo rubber was to adopt, as the chief problem, the introduction of mechanical processes for extracting the rubber contained in the plant tissues. We made it plain that this method was recommended solely for the economic development of the Centre and Western portions of the dark Continent.

It was not the first time I had recommended this course. I have advocated the principle for many years. It has found, among the official agriculturists of various colonies, a number of opponents, and to this day mechanical processes have not been applied in Africa.

The recent crisis has, on the contrary, made the opponents of the cultivation and development of rubber vines hold their heads still higher, and we have even heard the total abandonment of such enterprises advocated. They have gone so far as to say that vine cultivation was of no value to the natives, who would readily waive their right to gather rubber in the forests, if they were offered in exchange easy and remunerative work in connection with other kinds of agricultural enterprise. These views are superficial, for there is no proof that the native will so easily abandon his rights ; but even supposing they were correct, would it be advantageous either to the Colony itself or to the metropolis to adopt a course leading to the suppression of an important industry, and to a radical and relatively sudden change in the habits of the negro ?

Fortunately, there are a certain number of colonials who are of our way of thinking. Quite recently one of our French colleagues, M. Bandon, writing with reference to the production of rubber in the French Congo, has made a report on the rubber extracted from *Landolphia ovariensis*, in which he arrives at the same conclusion as the writer, and advises the multiplication of the vine with a view to ensuring a fixed yield. He further advises that when they are full grown, the roots should be removed from the soil for mechanical treatment.*

M. Merlin, Governor of French Africa, has also recently recommended this method of cultivation, and naturally his ideas have again made the round of the special Press, having been reproduced, without much comment it is true, even in the German rubber reviews.†

The perusal of these publications of M. Bandon and Governor Merlin has led us to open the subject anew, first calling attention to certain dates which seem to us significant ones in the history of rubber.

In 1907, in a communication to the Scientific Society of Brussels, and published in its Bulletin reproduced by the Eastern Geographical Society, I put on paper, perhaps for the first time, the idea of systematically working the rubber bearing vines growing in the forests, in the following words : " The exploitation of at least those species of wild rubber most commonly cultivated in the Congo (*Landolphia ovariensis, Vilainei* and allied species) must be limited to the operations of cutting and extracting. After cutting they must be allowed to grow again. In a word, the rubber reserve must be made to produce a regular yield." We were under no delusion at that time as to the difficulties of getting this principle admitted, for most of the Colonial Governments had by decrees forbidden the tapping of rubber vines, and in certain Colonies this prohibition still obtains. But we feel as sure as we did in 1907 that the time will come—may it not be too long delayed—when it will be recognized that cutting does less injury, and is more profitable, than tapping.

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* A. Bandon.—" Le caoutchouc pilonnè des rhizmes du Landolphia Ovariensis, Pal. Beauv., sa production, son avenir." Annales de l'Institut Colonial de Bordeaux, 1913.

† Cf. Gummi-Zeitung for 1914, No. 30, 24th April, P. 167.

To quote once more from the 1907 paper: "When cutting shall be permitted, when the rubber forests shall have been made to give a regular yield, like our European forests, when rotation shall have become definitely fixed, and when we know the exact area capable of being cultivated, many crying abuses will cease naturally, and it may even be possible to eliminate those fluctuations in prices which are so disturbing to the course of good trade." I was, then, probably the first to advocate the cultivation of rubber reserves in Africa by regular cutting.

It is true that even before this date I had advocated in lectures, conferences, and publications the principle of cutting and mechanical extraction which, however, is not my invention. It cannot be sufficiently emphasized that the original idea dates back to the researches of Godefroy-Leboeuf, which in turn are based upon the methods in use by the natives of Africa.

I have, however, advocated ever since 1907 the regular and systematic cutting of rubber-bearing vines and shrubs, and I have often written on the subject in the French journal "Le Caoutchouc et le Gutta Percha."*

Not long ago an official of the forest service in Madagascar put forth a project for the cultivation and management of rubber-producing forests, which was founded on these views of mine.

But the question of the cultivation of rubber vines is, like all those bearing on rubber growing, much more complex than is frequently imagined; for it raises a whole series of accessory questions, unfortunately too little studied.

Admitting what seems certain to us, that cultivation is possible, is it economic? Will not the expenses be so great, especially under present conditions, as to leave to the collector and the merchant insufficient profit? Many have concluded, we think after insufficient investigation, that a profit from such an enterprise was impossible, and for that reason they have not only counselled the abandonment of vine cultivation, but have condemned the exploitation of vines already existing in the forests. Their idea is that all efforts should be diverted to the planting and exploitation of *Hevea Brasiliensis* or of *Manihot*, these being the only species (particularly the former) which will yield suitable rubber at a profit.

With regard to this idea, we have noted the following remarks by M. R. Vauthier, Member of the Colonial Council of the Belgian Congo, with reference to a decree approving a treaty concluded between certain Belgian and English firms and the Government of the Colony: "The collecting of wild rubber has only been a provisional enterprise till better methods are found. It depends upon natural resources which are destined to become exhausted more or less rapidly. Now, however, long before these resources were exhausted, has come this remarkable falling off in the price of rubber. A crisis has been the result, and it has adversely affected the finances of the Colony."†

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* Le Caoutchouc et le Gutta Percha. Paris, Rue des Vinaigriers 49—1904-1914.

† Le Mouvement Gèographique, Bruxelles 28 dic, 1913. P 661.

We cannot agree with these views. The Congo is not so impoverished in rubber as to make it necessary to consider the suppression of this article of commerce. On the contrary, we think that exploitation will continue if we wish it to, perhaps not of wholly wild vines, but of vines which are cared for by the natives; this will naturally be the case if the Governments will supervise the work and demonstrate to the native, who in many cases already sees it for himself, that it is in his interest to protect rubber producing plants.

I have already stated as my opinion that the rubber produced by the wild plants in Africa is capable of giving the collector and the merchant a remunerative profit, even with the present low prices. Is this view a sound one?

In dealing with Colonial matters, especially questions concerning rubber, it is necessary to guard against preconceived ideas. One must, on the contrary, seek to consider the subject thoroughly, and should avoid hasty conclusions which might subsequently have to be revoked in the light of new developments.

An address made in 1913, by General Thys, whose reputation in Colonial matters is well known, contains some very true statements about Congo rubber. "With reference to our rubber companies," he says, "I think they will have to take great care with their management, and apply themselves diligently to the reduction of expenses. In all cases the prices paid to gatherers or traders for rubber should compare properly with the prices that the rubber will realize in Europe. Finally, and above all, they must take the greatest care in choosing their European staff, for of all the dangers pointed out, this is the most to be feared, and the least talked about and thought about. In my opinion, the greatest of all difficulties is to find a good European staff in Africa.*

We have no intention of developing the various points raised by General Thys, although in view of their importance, they deserve to be discussed. We simply retain the impression that the rubber crisis is not so serious as many have thought it to be. This opinion, moreover, is shared by G. Lamy-Torrilhon. "We must not be too much alarmed," he says, "at this state of affairs, for it will gradually become more settled. Normal conditions will come again, let us hope, without too great a loss to the gatherers either of 'plantation' or of 'wild Para.' Meanwhile, let us learn a lesson from what is taking place at the present time. This crisis, which principally affects Brazil and the Congo, will gradually pass away. We had grown too quickly accustomed to exaggerated profits; had spent without counting money that had come too easily. It will now be necessary to reduce expenses and the cost of hand labour to what is strictly necessary, and to limit expenditure in every direction."†

To cope with this crisis all the Governments interested have sought to modify the existing regulations, and to reduce the costs of transportation, so as to put wild rubber on the market at a price capable of competing with 'plantation' rubber.

The crisis, which is already passing away (for as a matter of fact prices are rising), should not, therefore, lead us to abandon the cultivation, nor even the development, of the native products. Brazil is about to see itself surpassed in rubber production by the Far East; but does it follow that Brazil should no longer, and can never again, export rubber? That would be, it seems to us, a hasty and far-fetched conclusion. The same thing applies to the Belgian Congo, which for many years has exported annually about 4,000 tons of rubber. Shall we hastily assume that as a result of a mere falling off in prices this vast area is no longer capable of producing rubber profitably, and that consequently the country that has furnished this vast amount of rubber must now cease to exploit it? On the contrary, let the industry be carefully studied. Let money be saved, and above all, suit the purchase price to the selling price and it will be easily possible to keep rubber among the exports of this Colony, under conditions which will give all kinds of traders reasonable profits.

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* Le Mouvement Geographique, Bruxelles, U dic. 1913. P. 646.

† G. Lamy-Torrilhon.—"La Situation Economique," Journal d'Agriculture Tropicale, No. 149, 30th November, 1913.

The proposals made by the Government of French Equatorial Africa for reduction of expenses correspond to a reduction of 0.785 frs. per kilo., or 785 frs. per ton; this would make the price of rubber per ton 2,750-785 = 1,965 frs., to which amount it would, of course, be necessary to add the cost of transportation to the European market.*

In these figures the purchase price of rubber is fixed at 1 fr. per kilo., which is the official figure proposed by the Minister for the French Colonies in the Official Journal of the 14th March last.† But the Minister for the French Colonies has carefully drawn attention to this price as being "generally speaking, higher than that paid by the traders in the country where it is produced."

When we were considering the profit to be expected from the wild rubber plants in the Congo, and took as our basis the price of 1,381·25 frs. per ton for Congo rubber delivered in Antwerp, we had added 750 frs. as the purchase price paid to the native. This raised the price per ton to 2,131·25 frs. delivered at Antwerp, while the very lowest price obtained in December, 1913, was 3·50 frs. per kilo., that is 3,500 frs. per ton. This leaves a net profit of over 1,300 frs. per ton. Even admitting that one must pay the gatherers 1,000 frs. per ton, which would make the cost at Antwerp 2,381·21 frs., there would still be a very notable profit per ton. We must, moreover, take into consideration that the actual average of the purchase price on the Antwerp market is 4 frs., and that this more than covers the supplementary expense for the purchase of the raw material in the Congo.

The sale price, moreover, has gone still higher, and on the 25th April the quotations at Antwerp for Congo rubbers of fine quality in great demand were:

	Fr. %.	Kilo.
Congo Upper Ubangi red	5·90	6
H.C. ordinary red	5·65	5·85
H.C. black	5·80	5.90
Kasai red and black I.	5·75	5·85
Sanga Ubangi black	5·90	6
Katanga black and red I.	5·85	5·95
Alima	4·95	

That is to say, the lowest sale price of the product exceeded the figure we have quoted.

It should be said, however, that a portion was withdrawn from the sale, the sellers not wishing to accept offers showing too great a drop in price. Nevertheless, the sale price of African rubber could be easily maintained at about 4·50 frs. per kilo. or even higher. It would only be necessary to improve the quality. This can be brought about by simple washing, and still more surely by instructing the native, as has already been done in certain African Colonies.

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* Cf. Bulletin de l'Association des Planteurs de Caoutchouc, Vol. VI.., Mar., 1914, No. 2. P. 35; see also p. 39.

† Quinzaine Coloniale, Mar. 25, 1914. P. 203.

Governor Merlin has pointed out the fact that certain important firms, such as the Provodnik of Riga, while recognizing the superiority of plantation rubber as compared with wild rubber have nevertheless affirmed that the complete substitution of plantation for wild rubber would take a long time ; furthermore, they have shown clearly the interest they would have in Congo sorts, especially if the quality were better than that offered heretofore.

We think it important, however, to point out that first quality Congo rubber, which is very rare, has an exaggerated value. To be convinced of this it will suffice to glance over the prices of rubber offered on the Antwerp market in April 1914. (Grisar's Circular, 20th March, No. 7.) We find the prices of wild Congo rubber fluctuating between 2·50 frs. and 6 frs. per kilo., while those of plantation rubber vary from 4·80 frs. to 6·85 frs.

As the price list given above shows, French Congo (Alima) seems to present less favourable conditions than Belgian Congo.

There is not, therefore, a very great difference between plantation and " wild " rubber there, and it is incontestable that the washing on the spot, the education of the native, and the use of more rational processes would make it possible to obtain Congo rubber of finer and finer quality always to be relied on, at least equal in value to the maximums now obtained, capable of competing more and more easily with plantation rubber.

It is, moreover, an object towards which all efforts must tend, to diminish the number of varieties of rubber brought into the market, and by improving their quality, work toward " standardization," as desired by the Rubber Growers Association of London. This is, however, a very obscure and difficult problem which cannot be solved except by numerous researches in pure science and in industrial practice.*

Unquestionably the competition between the two products will be keen, but we believe they will both survive. It must, however, be admitted that producers of either kind who have not sufficient vigour —that is to say, who are not sufficiently well equipped—will disappear, unfortunately for themselves, but fortunately for the good of the cause. Indeed, this has already come to pass. Rubber companies formed at the time of the boom which were really over-capitalized must fail, for the present conditions do not allow them to pay dividends, but it is quite otherwise with the returns from wild rubber, based on the co-operation of the natives.

We, therefore, think that the management and cultivation of rubber vines is a profitable business. The experiments we have reported in former papers : M. Laurent's Mission and the Permanent Mission for Research Work of the Kasai Company have proved that it is possible to bring about the multiplication, not only of the high-climbing rubber-producing vines, but also of those in which the latex has run into the roots (rhizomes) owing to the particular surroundings under which these plants exist, and certain forms of *Landolphia ovariensis* on which M. Bandon has made his very important experiments.

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* Cf. Bulletin de l'Association des Planteurs de Caoutchouc, V., May, 1914, No. IV.

But it is indisputable that to obtain results with these rubber plants, they must not only be submitted to regular cutting, as we have said and as M. Lowel of Madagascar and M. Bandon of French Congo have since said, but the cuttings must be mechanically treated; for in this way only is it possible to handle and manage these plants methodically and economically.

M. Bandon thinks that the development by private persons of wild rubber in Ubangi-Chari is impossible, because of the remoteness of the countries where it is necessary to work, because of the difficulties of every kind met there, and also because of the scarcity of labour. He also believes that to succeed it would be necessary to operate very extensive estates. This would require a very large capital, so large that according to him, the yield of the estate could not pay dividends; but he considers that the question is quite a different one if the work be done by the Government, which would, as he says, work in "the interest of the native by requiring from him an effort that would yield him the greatest profit."

We do not altogether share these views. A private enterprise well conducted could, we feel sure, by this method of management, make sufficient profit to remunerate suitably a capital properly proportioned to the economic possibilities of the enterprise. Most certainly an enterprise of this kind would be managed differently from the ordinary plantations established in the African Colonies. It would also differ from the estates of the Far East. For example, there would be nothing in the treatment of rubber-bearing vines, unless it was permitted to cut them and unless the taking up of the roots and cutting of the useful plants were done in zones.

On the other hand, nothing could be easier for a company possessing a forest grant or lands covered with rubber shrubs to cut these regularly and to transport as required into the zones under cultivation the apparatus necessary for the mechanical extraction of the rubber. If this gave no results, would it not be possible to make the natives take the raw material to a manufactory built on the estate on a favourably chosen site. In this case the native would only have to look after the reserves and collect the raw material that he would deliver at the factory, and receive payment proportional either to the plants and roots brought, or to the rubber extracted from the raw material. This highly commendable method, according to our way of thinking, would not demand very heavy work from the native; it has, in the case of other products, cacao for example, given very good results in certain Colonies of West Africa.

It is, let us not forget, much more to our interest to make the native work on the spot, to improve the actually existing industries, than to seek to create in every direction new industries or new products for which the native can as yet have no aptitude.

Should it be feared, moreover, that even under these conditions European capital could not be sufficiently remunerated, there remains the by no means to be neglected possibility of directly encouraging the original native method of working the vines, *i.e.*, by cutting and pounding. Factory officials, either whites or natives, could then buy this rubber, as has been done for many years by rich European capitalist companies. In this case there might be some advantage in cleansing the rubber at a central factory before sending it to Europe, thus regulating and improving, if possible, the quality of the product.

We cannot deny that there are many localities which are, and will be for very many years, at a great distance from any metropolis. It will not be possible to introduce there any kind of intensive cultivation; but rubber, if found there, will always be a product that will find a buyer with satisfactory results.

Governments ought naturally to intervene in circumstances like these, only to see if the conditions under which the natives work on behalf of private companies are within the limits of the regulations that the Colony has enacted; and also to see that preservation of the reserves is assured. That, according to our way of thinking, raises no difficulty. Commercial firms that hold concessions have, in most of the Colonies, to observe certain specifications as to forest management. The production of rubber from vines, even outside the forests, as in the African bush, should be put on the same footing as the management of other forest products.

Madagascar has regulated in this manner the exploitation of rubber by its decree of the 28th August, 1913. The President of the French Republic, acting on the report of the Minister, M. I. Morel, has decreed as follows:

> Art. 46.—The gathering of gums, resins, gutta percha, india-rubber, latex of all kinds and all other accessory products will be carried on according to the instructions of the Colonial Service, so as not to destroy the productive plants. Specifications of the special clauses will be made for those Companies that adhere to the general rules as under:
>
> 1. Cutting down rubber trees is strictly forbidden; only vines having a diameter of over 4 centimetres may be cut; rubber from trees is to be obtained solely by tapping.
>
> Art. 47.—As to rubber, the owner of a concession will be further required to plant each year in the areas under cultivation a number of vines and rubber trees which will not be less than 150 trees per hectare. Specifications of the special clauses will indicate the conditions under which these plantations will be made.

We are of opinion that the cutting down of certain trees might well be permitted. We have previously proved, and M. Farrenc has taken up the same theme, that *Funtumia Elastica* could with advantage be cut down, and its bark mechanically treated.*

It would suffice to insert in the section on the gathering of rubber, the restriction introduced by the Madagascar decree relating to gums and resins: "The owner of the concession may employ whatever method of extraction he prefers, provided it is not prejudicial to the future of the forest."

It would, perhaps, be necessary to replace the words "owner of concession" by "collector" and to insert the qualifying word "economic" before the words "future of the forest."

The management of vines, therefore, has still a future. Above all it requires study; it ought to be made the subject of an enquiry without preconceived ideas. From this study there would naturally result well defined regulations, which States, commercial companies and the natives would find it to their interest to see enforced.

The regulations should, of course, take account of the plants collected, these being, as we have had frequent occasion to say, very varied. Here, then, we have a further reason for bespeaking for all the resources of Tropical colonies thorough scientific and economic enquiries, without which all our cultivation enterprises will be based on empiricism, and in most cases doomed to failure.

This is, moreover, one of the conclusions reached by our colleague, M. Bandon; for he expressly says: "It is necessary to recognize, from the first, all important planting of new trees, to limit them in their range and set them in the local maps. This would be the heaviest work, but it could be done quickly enough by the Government agents in the course of their journeys made in their respective districts."

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* Cf. De Wildeman in "Le Caoutchouc et le Gutta-Percha," 15th February, 1914, p. 8019, where Bibliographical details on the subject will be found.

When, on the occasion of the first Rubber Congress in London in 1911, I urged the interest there was in the cultivation and exploitation of rubber, I suggested that rational management would have as its result the attachment of the native to the soil, which would assist civilization more than bringing the native to work for the white capitalist on plantation or in factory.

It should also be borne in mind that rational improvement of the forests, and of the African bush, would have the great advantage of preserving these forests and these lands covered with vegetation, thus preventing, by the simple protection of the soil, the modification of climate and the gullying of the land, which have the greatest influence on the economic future of tropical regions.

Already in the English Indies, in the Netherland Indies, and in Madagascar, agriculturists are drawing attention to the great harm arising from the clearing away of forest trees, which brings changes against which, alas ! human effort cannot contend. Has not M. Louvel calculated that for a single province in Madagascar (Morondava) 2,000 hectares of surface covered with wood is annually destroyed by natives Add to this the many hectares of forests that the white man cuts down, to make room for plantations often eventual, and imagine how much will remain in a few years of the tropical forests and resources on which we so much depend.

It is much to be desired that the wishes only recently expressed by Mr. Altona, of the Forest Service in Java, and by Mr. Harold Hamel-Smith, of London, should be fully taken into consideration. Their fulfilment would compel the Governments of the tropical countries to take measures for the rational management of the resources of their forests.

The CHAIRMAN (Dr. Torrey) : The author's point of view while it is an ancient one in these days, is expressed with an amount of conviction that deserves attention. By the way, has the exploitation of *Funtumia* from a market point of view altogether ceased ?

Mr. W. T. GIBSON : I think it is still coming over from the Congo. I do not remember that the word " tapping," in its proper sense, occurs in this paper. What Dr. de Wildeman recommends here, and in his former paper, is cultivation of the vines until they have reached a certain size, and then by cutting down a certain distance the vine would develop again. Meanwhile the product from the cut portion of the vine could be mechanically treated. The idea that he had was that a large enough area should be worked, so that a part of the vine forest would always be growing again. It would be divided up into several sections worked in rotation in such a way as to give the cut sections a chance to grow sufficiently before the next cutting. So long as the cut was not more than a certain distance above the ground Dr. de Wildeman thought the vine would branch with extreme vigour.

Notes on the Philippine Rubber Question.

By

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The rubber-producing world has been wondering for several years why the Philippine Archipelago is not producing, or obviously in a way to produce large quantities of plantation rubber. The question presents several rather unique peculiarities, but, putting it briefly, the two principal causes of this deplorable non-production are: (1) Natural, that is, climatic and locational disadvantages; and (2) Cultural, that is, errors and malpractices of the planters themselves. While British Malaya and British North Borneo are planting Hevea extensively, there is comparatively little being done in the adjacent region of the Philippine Archipelago, viz., the Sulu Islands and Mindanao, where the climate is admittedly similar to that of the aforesaid Colonies. There are, however, in Mindanao two so-called dry seasons with somewhat more wind movement than either Borneo or the Malay Peninsula are troubled with.

In the north-central and central portions of the Archipelago rubber has been planted extensively, or rather, widely, for the past ten years; of the hundreds of thousands of trees set out in scores if not in hundreds of small plantations, not one thousand even moderately good young trees are in evidence to-day. This is accounted for by the inexperience of the planters themselves and the prevalence of long droughts during six or eight months of the year, and frequent occurrence of typhoons throughout the middle section of the Archipelago. A campaign was started four or five years ago at the time of the great boom in Pará throughout the Orient, and several promoters aroused considerable public interest and succeeded in getting two or three of the principal newspapers to take up the question with some success from their point of view. The Bureau of Agriculture of the Philippine Government, however, endeavoured to restrain the over-enthusiasm of these promoters and would-be planters, pointing out the risks and dangers, not to say losses, which would almost necessarily follow the planting of this moisture-loving rubber species in situations where it would certainly suffer from drought and strong winds. The matter came to a crisis in 1910 and 1911. The Bureau of Agriculture was criticized very severely for its apparent pessimism, and attempts were made to draw the Bureau's experts into a newspaper controversy—without success, of course.

Planters who knew nothing of the requirements of Pará ordered vast quantities of seeds from Singapore dealers, and were quite content with a germination of 10 to 20 per cent.; their nursery methods were execrable, and consequently the seedlings were never in good condition for transplanting; the sites chosen for setting out the exceedingly bad lot of stock were frequently on sandy hillsides, open to the strong wind currents, or in sour wet clay soils where the roots rotted about as fast as they grew. No attention was paid in most cases to keeping the highly injurious grass away from the young Pará roots, and worse than *that*, perhaps, no fences were built around the plantations; wild pigs, deer, and other pests ran riot through the plantation, uprooting the trees or browsing off their tops at their sweet will. A few of the planters, acting upon the advice of the Bureau of Agriculture, tried to keep down the grass and weeds by hoeing or planting beans and other catch crops around the trees. These troubles, coupled with the droughts, however, in nearly every case killed the trees in from one to three years. It is impossible to estimate the amount of money wasted through these errors of judgment and the sad lack of experience, but it must unquestionably run to many thousands of pounds; and these failures have unduly frightened the more conservative, if not more intelligent, class of planters.

In Mindanao, where one would naturally look for vast and very prosperous plantations, we actually find but one which can be called even slightly profitable. This (La Basilan Plantation Co., Inc.) is located in Basilan, just south of Zamboanga, and contains only some 350 acres, including trees below the tapable age. A few hundred Pará trees on this estate are now producing fairly well, and samples of the output are exhibited at the Philippine Stand (No. 152). This rubber is said to contain only one-quarter per cent. of resin, and therefore must be considered one of the most nearly resinless of all plantation rubbers. For various reasons the Directors of the Company have decided to plant the larger part of the land with coconuts, and by the end of 1915 the 33,000 coconut trees will occupy some 650 acres, or about double the Pará area.

Several plantations of Pará and one remarkable one of Castilloa are in evidence around the south and west coasts of Mindanao. The interior of the island is almost entirely uncultivated, with the exception of a few estates and one large rice colony on the Rio Grande, or Cotabato, river in the west central part. On the Davao Gulf, in the south-eastern part of the island, a considerable number of Pará trees, widely scattered and practically abandoned in most cases, may be found by the rubber expert if he has time to make a survey of the coasts of this gulf. The Castilloa plantation at Lais on the west coast of the gulf is most interesting, especially since the trees have made what appears to be a record growth—even excelling the planted Castilloa in Mexico itself. The first two blocks of scrap from these trees, which are now about seven years old, are exhibited in the Philippine Section of the present Exhibition. They are somewhat tacky, to be sure, but considering the manner in which they were made up, the quality is all that could be expected for the virgin crop.

Ceará is quite out of the running at present, and especially on the Basilan plantation, where the trees which were just beginning to yield were uprooted some time ago. No Ficus has been planted anywhere.

Two species of indigenous vines, occurring more or less commonly throughout the Mindanao and the jungles of the central part of the

Archipelago, are actually used to a slight extent by the native tribes, who occasionally tap them (destructively) to get rubber for their drum-stick heads and for trading; and in Western Mindanao rubber of the Tabango Vine (*Chonemorpha elastica*) is mixed with gutta-percha and sold to the Chinese dealers, who allow in trade the same number of matches or sardines for a chunk of the true rubber as for the gutta. Another vine, the Dugtung-ahas (*Parameria philippinensis*) also yields rubber, and on account of its large size may eventually become of some importance when skilled rubber tappers are available to make a thorough search of the forests, at least in the vicinity of transportation routes—which are conspicuous by their absence in this very large island (200 miles from north to south and 300 from east to west). The gutta-percha output of Mindanao probably exceeds 100 tons per annum, but the Chinese traders, who are naturally very suspicious of any sort of investigation are liable to mislead anyone in search of statistics, and, by the way, the gutta-percha of Western Mindanao goes almost entirely to Sandakan and Kudat, from whence it is re-shipped, with or without cleaning, to Singapore as the product of British North Borneo. Until very recently all of the gutta was collected by the natives of the hinterland, who fell the trees and then cut rings round the prostrate trunk, placing banana leaves beneath these rings to catch the latex as it drips from the cuts; a large part of the latex is left in the bark, of course, and, worse still, no species of the gutta trees (Palaquium) ever sprout from the stump. The Bureau of Forestry is endeavouring to regulate the tapping of gutta trees in Mindanao, but it is practically impossible to induce the wild tribes of the interior to change their abominable methods of extraction; as a Moro chief once remarked to me, "the Bureau's methods are all right for the natives near the coast, but are no good in the interior."

Vast forests extending from Davao on the south-east to Zamboanga in the extreme west contain a fair amount of gutta-percha, badly scattered, however, and no-where in pure stands.

It is out of the question for a white man to travel through the interior of this area, and consequently the crude gutta, filled with bark, sticks, and even stones, goes down to the coast into the hands of Chinese traders, who pass it on to the Chinese middleman in Cotabato and Zamboanga. A first-class plant has been established for nearly a year at Cotabato City, a few miles up the river from the mouth, and this factory is now turning out pure gum, which is probably a little better than anything produced in either the Dutch Indies, Borneo, or British Malaya. Samples of both the crude gum in twists and balls, as well as high-grade blocks from the factory, are in evidence in the Philippines Section of the current Exhibition.

Finally, as to the future outlook for Pará in the Philippines: the present difficulties with labour will gradually be reduced to an easy working basis, at least in the coast districts of the Southern Islands; the encouragement extended by the Bureaus of Forestry and Lands will enable either an individual or a corporation to purchase or lease, at very reasonable terms, suitable land for Pará planting; the climate in Mindanao is probably as good as that in any part of Borneo or Malaya; the soil, though highly variable, is, generally speaking, rich, and of fair depth. Unless the price of rubber should fall considerably, therefore, it is probable that the next decade will see a considerable extension of rubber planting in this section of the Archipelago. The boom has passed, and will probably never worry many planters, press agents, or Government experts again. It is now up to the intelligent planter to choose the highly profitable abacá, or Manilla hemp, the steady and reliable coconut, or the famous Pará—or better still, some combination of two or three of these crops, to provide him with his income.

Another question, which is a very delicate one, is the matter of politics and governmental backing of the enterprise. The most that can be said on this subject at present is that rather large amounts of British, American, and German capital are lying in the offing waiting for a favourable breeze to sail in to the golden harvest of commercial products, among which rubber will certainly be represented, in this very rich but, thus far, practically undeveloped section of the Philippines.

The CHAIRMAN: This paper has answered some questions on which definite statements have been needed for some time. Perhaps the speaker will subsequently tell us what the soils are like. He speaks of rubber being planted in some soils that were unsuitable, and perhaps he can let us know whether there are also soils that are favourable. Doubtless there are other speakers more familiar with the ground than I am.

Mr. O. W. BARRETT: I tried to distinguish between the non-productive areas of the Philippines, the north-western and central areas, and the southern portion. There is a pretty sharp distinction between the central portion and the southern islands, including Mindanao, where we get two rainy seasons in the year as compared with only one in the other parts. In the south the soil is volcanic. In the central and north central portions it is alluvial, with sandy loam, ordinary loam and yellowish red clay. In the southern part it is deeply volcanic loam, sometimes with water-bearing strata four to six feet below the surface. The trees sink their roots deep into it.

The CHAIRMAN: For what is that soil suitable?

Mr. BARRETT: Undoubtedly for *Abaca*, but *Hevea* seems to do very well when it has decent care. The fault is not with the tree or the soil, but with probably the most inexperienced assemblage of planters the world has seen, trying to plant Para rubber. They have planted without any regulation, and 99 per cent., as was to be expected, are "in a hole now." So far as climate and soil go, and the regulations regarding titles, etc., the locality is quite suitable. Another point I did not touch upon was that of labour, which has improved.

The CHAIRMAN: That is, native labour?

Mr. BARRETT: Yes.

The CHAIRMAN: How will the price of labour compare with that in the Malay States?

Mr. BARRETT: It is a little higher, but not very much—roughly, about 25 per cent. Of course, there is always the floating population, which works on the rice plantations. On the Basilan Plantation the savage Moro is giving good satisfaction as a tapper. He says nothing, and minds his own business very well. When once shown how to use the knife, he carries his brains in his fingers, as it were, and in this case the fingers make the right man.

Mr. BURGESS : Is that area politically settled, or is there tribal trouble ?

Mr. BARRETT : In Mindanao there are tribal differences. In the eastern portion of the island there are three or four pagan tribes, and also the Moro, who always stands up for his own religion, and hates the pagan tribes. It requires a good man in the field to prevent friction between these different classes of labourers. There have been very few cases of bloodshed ; there simply has been friction, and always will be between these people. Along the western coast and the north, the Basilan labourer is coming in. The families are taken out, fifty people at a time, by the planters. They live on the plantations, working more or less all the time, and tilling gardens for themselves. It is not contract labour, but amounts to the same thing. These people are in fear of the pagan tribes. There again comes in the skill of the labour " boss."

Mr. EWART BARBARY : I would like to know whether Mr. Barrett can give us more information concerning the gutta-percha from the Philippines. On analysis it appears to be of quite different quality from that which is sent from Java. The gutta hydrocarbons differ greatly, and the two samples seem to be of altogether different construction. If Mr. Barrett can give further information as to the species of tree the Philippines gutta comes from, it will be very useful to us in the future, I am sure. Whether it is a real gutta or not seems to be the question. The gutta from Java is useful for golf balls and such purposes, but for the purposes of the cable industry or for waterproofing, that from the Philippines seems to be of better quality.

Mr. BARRETT : I am very sorry, but I have been quite unable to get information on this point. Our botanists have not done much to help us. It is very difficult to get back into the interior where this gutta comes from. There are three or four different trees yielding gutta, but our botanists have never tried to show us which species are most in evidence, or which give us the best product.

The CHAIRMAN : I am not familiar with this particular gutta of which you are speaking, Mr. Barbary. Why did you remark that it was questionable whether it was true gutta ?

Mr. BARBARY : Because in the counter extractions you get all kinds of gutta hydrocarbons. The molecular structure is altogether different.

The CHAIRMAN : You meant, molecularly speaking.

Mr. BARBARY : This product has more elastic properties than the hydrocarbon from Java. What is sent from the Philippines is gutta. That on view now in connection with the Philippine exhibit has more of the gutta quality than the Java leaf gutta.

Mr. BARRETT : May I add that the blocks which are in evidence in the Philippines exhibit have been put through a more or less secret process in the plant. Having visited the plant as an ordinary observer, my impression is that gasolene is used in removing the bark and stones from the twists and balls, and some liquid hot gum coming from the tanks is simply run into empty kerosene cases and then sawn through into ordinary blocks for packing. They should come direct to England, but I am much afraid they go to Borneo, because the Chinese have regular routes of trade that it is very difficult to upset.

The Best and Most Economical Methods of Tapping.

By

W. F. de BOIS MACLAREN.

The subject of my remarks to-day is, as you are aware, "The best and most economical methods of tapping." In the time at my disposal it is impossible to describe and to discuss all methods of tapping, and I therefore do not propose to take up time over bad and indifferent systems, although it may be necessary to allude to some of them in passing.

What constitutes a good system of tapping? It has been described as "The best method of tapping is that which extracts the maximum amount of latex from the tree with the removal of the minimum amount of cortical tissue and without damaging the thin layer of cambium cells." I hope that I may be pardoned if I demur to the definition as not being sufficiently broad and inclusive. In the statement I submit to you to-day you will find other and quite important conditions laid down as to what is necessary to constitute a good all-round system of tapping.

The importance of selecting the best possible system of tapping has a more direct relationship to financial results than has been generally recognised. The difference between a good system of tapping and an indifferent one may amount to several thousands of pounds sterling per annum according to the areas in bearing. This may appear a startling statement, but before I have finished addressing you, I hope to be able to convince you that there is no exaggeration, but that, on the contrary, the facts are plain and capable of only one interpretation, and that interpretation the one I give you, namely, that by their present methods of tapping some estates are annually losing some such amounts. Now, many estates cannot afford to lose even £2,000, £3,000 or £5,000 per annum. The all-in costs of quite a number of estates—estates producing a considerable amount of rubber yearly—have, till recently, not been very much below two shillings per pound, and with rubber selling at an average price for all grades of say 2s. 2d. per lb., the price ruling when this paper is written every penny of saving is important.

In considering which is the best system of tapping to adopt one has not only to consider which method is best for the trees and gives the largest yields of rubber, but also, which is best for factory working. It will be evident on a moment's consideration that if satisfactory yields of latex are forthcoming by adopting a system of only two quarter section cuts or one half spiral or one broad V cut, then, as compared with methods which involve four, five, six or more cuts, the system of few cuts is best from a factory point of view. The fewer the cuts the smaller will be the proportions of scrap rubber, bark shavings and earth rubber to the first latex rubber. If, instead of having 40% of low grade rubber and 60% of first qualities—a common proportion when the quantities of scrap, bark shavings and earth rubber are in excess—one gets 80% to 85% of high grade and only 15% to 20% of inferior qualities, the cash difference is quite equal to an extra penny per pound overhead on the total output of the factory. From this point of view alone a system involving few cuts ought to strongly recommend itself to those responsible for the management of plantations. Further, as everyone knows, there is more wear and tear and damage done to machinery in one month in treating scrap, bark shavings and earth rubber than would otherwise be the case in the course of nearly a year. The more, therefore, the proportions of these low grade materials can be reduced, the better for the factory. This remark does not apply to large factories which employ Universal Washers.

The effect of a system of few cuts on field working is also worthy of attention. With few cuts on one side of the trees as against the two side tapping which is unfortunately so common, only half the number of spouts and cups is required. From the point of view of the welfare of the trees, cuts on two sides at the same time are entirely objectionable. Where only two short cuts or one longer cut on one side of the trees are made, the tapper's task can be considerably increased, and with a saving of twenty to thirty per cent. of the labour force. Hence smaller outlays for wages, and reduced recruiting, hospital and other charges. Supposing that a farthing on each pound of rubber is thus saved on field work in addition to the penny we have shown as saved in the case of factory working, the total saving is thus 1¼d. per pound, or the equivalent on a total output of, say, 400,000 lb. per annum, to a saving of £2,083 6s. 8d. Such a saving is surely well worthy of the fullest consideration, and if the system of few cuts advocated really involves, as I believe it does, a saving of some such amount with as large or larger yields, then it is clearly the duty of all in charge of plantations to carefully investigate the subject.

Considering the problem before us from every possible point of view, I think the best all-round system of tapping is to tap the trees daily with two cuts only on the quarter section on one side of the tree. Some prefer to open with one cut only, about 12 inches from the ground, and assure me that they are certain that they get quite as large a yield of latex from one cut as they obtain when they make two cuts, and that it is better for the trees. So far as I am concerned I leave the matter of one or two cuts on the first quarter when starting tapping an open question, favouring one cut if it is generally found on longer experience to give equal, or even almost equally good results. It is assumed that when first tapped the trees will girth at least 18 inches, and preferably 20 inches, three feet from the ground. If it were not for financial reasons I should very much like to delay tapping for the first time till the trees were 25 inches, three feet from the ground. If this could be agreed upon I am certain that we would have infinitely finer trees to tap, better grown in every way, and with roots three to five times larger than trees of the same age which had been regularly tapped since they were 18 inches in girth. For every pint of latex the long tapped trees yielded, the trees whose tapping had been long delayed would, in my opinion, soon give double, and I leave you to decide which method to follow is the best paying one in the end.

Anyhow, it is clear to me that the longer the trees can be left untapped and undrained of large portions of their food supplies, the more robust will be the trees. One thing which impressed itself on my mind during my last visit to the East more than almost any other was the extremely poor development of the roots of the rubber trees. It is noteworthy in this connection that the spreading of the roots of heveas is very slow and limited till the trees are about four years old. Thereafter it is rapid unless interfered with by outside causes. Unfortunately, it is at this critical time that tapping is usually started and the root expansion checked. I saw some trees which had been widely planted, and the tapping of which had been delayed. The roots of these trees were magnificent, and could be traced for a great distance, and the yields of rubber were very large. On the other hand, trees tapped young, and especially those severely tapped, have starved, meagre roots. The food supplies manufactured in the foliage of the tree travel down from above through the inner cells of the bark. As the food supplies descend they are constantly first drawn on for the growth and renewal of the twigs, the branches and the stem of the tree itself, and the renewal of bark cut away. If bark is severely cut away so many channels of supplies are stopped. The roots, being last supplied and ill supplied, are starved. Now good roots are important to a tree. Poor roots inevitably mean poor bark renewal, as planters have recently begun to find out.

The danger of wounding the cambium of the trees is much less when tapping on bark of a proper thickness than when tapping above, say, two feet on the thin bark of trees of 18 inches girth. For this reason it is advisable not to start cuts too high or to have too great a distance between the two cuts on young trees when first taken into tapping. If one allows ten inches of bark area for each of the two cuts on the first quarter laid out, this confines the first tappings to moderately thick bark. Taking an average of twenty parings to the inch this would give a period of 200 days tapping for the first quarter laid out. The second quarter section should be laid out on the opposite side of the trees, for the reasons which I shall indicate. The tree will be of greater girth and the bark thicker than when the first section was started, and the two cuts may therefore be spaced at sixteen inches apart. This spacing should, at twenty parings to the inch, as before, allow a period of 320 tapping days by the time that section is completed. For the third section the spacing might be increased to twenty inches, which would be equal to 400 tapping days. By the time when it becomes necessary to lay out the fourth quarter section more than three years will have elapsed since tapping was first started on the trees, and if the cuts on the fourth quarter section are spaced twenty-four or twenty-five inches apart, then by the time the bark areas laid out have all been gone over for the first time a period of about four and a half years will have elapsed before it is necessary to tap any renewed bark. In the second cycle of tapping all cuts would be so much wider spaced that a period of fully six years would be easily obtainable for bark renewal. Five years I regard as the shortest period which should ever be allowed for bark renewal, after the first tapping, and six years is better.

The number of days in the year in which tapping is done varies very greatly according to climatic conditions. In some countries droughts last so long that it is compulsory to rest the trees for two or three months each year, and during the rainy season there are many days when it is quite impossible to tap. A well-known V. A. who knows S. India tells me that in certain districts they are lucky if they get 200 tapping days in a year. In a favoured country and district one may get an average of as many as 320 tapping days in the year, after making allowances for wet weather, for drought, and for native holidays. In districts where the number of days during which one can tap is much reduced one can, of course, estimate on longer periods before the bark being tapped is exhausted.

I have often observed on many estates that bark renews on trees very well the first time, fairly well the second time, but very badly indeed the third time when trees are being harassed by severe tapping. The Manager, misled by the first two good renewals of bark, finds himself in a bad position. The only real cure, seldom adopted, is to thoroughly rest the trees for at least two years in order that the tree may be restored to health and vigor. Till this is the case latex will be small in quantity and poor in its rubber contents if the partially renewed bark is tapped. I am glad to say that there is less over-tapping nowadays than was formerly the case, but there is still plenty going on. There are still V. A.'s and Managers of whom it might be said that, like the Bourbons, "They have learned nothing and have forgot nothing."

When the bark is finished on one quarter section of the tree it is not wise to start the quarter section on the opposite side of the channel. It is much better to tap a section on the opposite side of the tree farthest removed from the previous section tapped. The reason of this is that it keeps trees in distinctly better shape than if the adjacent section was next tapped. V. A.'s of old standing and much experience on many estates assure me that they have seen trees bulge quite out of shape—almost triangular in form—when tapping areas are not kept apart as long as possible in this way. It is clear, then, that this is a matter which should be kept in view. It is frequently, I fear, unthought of and neglected. Genius has been described as unusual ability in giving attention to details. This may be thought by some a mere detail and, therefore, unworthy of special attention. It is only, however, by constantly perfecting our methods of procedure in their every detail that we can make progress, and for my part I think this detail by no means an unimportant one, although I have never observed that any of the somewhat numerous—nowadays—book writers on rubber plantations have drawn attention to it.

There are some experienced planters who take the view that the broad V-cut or the half spiral, both of which extend right across half the tree, do not interfere with the proper passage of plant food supplies. They admit that these systems are opposed to all popular scientific views of aboriculture, but state that despite this the facts favour the practice. I desire to be entirely fair in the statements I put before you, and so would point out that among those who maintain that the best yields without injury to the tree are obtained from the single half spiral or single broad V-cut are such well-known representative planters as Joseph Fraser, of Ceylon, E. B. Skinner, of the Federated Malay States, and Mr. William Duncan, of the Straits Settlements. These planters are also supported in their views by Mr. Brain, the Government Director of Agriculture in the Federated Malay States, who has explicitly stated that while the yields continue excellent, the trees are uninjured.

I grant freely that during the first few years of tapping larger yields may probably be obtained by daily tapping on one side of the tree with a single broad V-cut, or better still a single half spiral cut, than by any other system of tapping. Certainly after trials extending over nearly two years, yields have continued to be excellent. It is also to be borne in mind that under such systems it is claimed that a period of fully six years is afforded for a thorough renewal of bark before retapping on the same areas.

Such systems of single cuts on one side of the tree are undoubtedly to be preferred above five, six or more quarter section cuts, or the two broad V-cuts or two half spiral cuts which I know are practised in Ceylon and in the Federated Malay States on a number of estates. Duplicating the cuts in this way gives actually smaller yields, not only per cut, but per tree, than are obtained from single cuts, and the period possible for a proper renewal of bark is so reduced that the estates will infallibly find themselves in the position of being forced to rest the trees for a more or less prolonged period or wastefully tap partially renewed bark for reduced yields of latex with a poor percentage of caoutchouc in it. Such disasters have been too common in the past. A leading V. A. told me personally that on one estate which he formerly visited he knew that the management had been alarmed to find at one time that the rubber contents of the latex obtained from the partially renewed bark which they were tapping was actually as low as one per cent.

I have personally seen trees not long ago on a leading Federated Malay States estate with no less than eleven cuts from which latex was flowing. What possible chance of bark renewal had such trees ?

Any system of tapping which involves cutting both sides of trees at once, whether the tapping is daily or on alternate days, is an unwarrantable interference with the trees, gives comparatively poor results even in the first few years, and later on, speaking from the experience in every case I have known, one finds the trees have been overtapped. In this connection I would refer to the fact that Mr. Morgan in his book points out that the poorest yields from the systems of tapping which he investigated were from trees tapped on alternate days on opposite quarters of the tree, and this result is in my opinion just what one might well expect.

The system of tapping employed has invariably a direct relationship to the proper distribution of food supplies throughout the tree. Any tapping at all is obviously an interference, no matter how slight, with the proper distribution of food supplies. Where tapping is severe and continuous the effects on the tree are very manifest. In judging the merits of any system of tapping, two important points to be borne in mind are what are the yields obtained, and what are the effects, present and future, likely to be on the tree. Any system such as the half spiral or broad V-cut, both of which half girdle the trees, and when the second year tapping cuts come to be made may be said to entirely girdle it, despite the fact that a portion of the bark is partially renewed—any such system, I would say, would appear to be bound to have detrimental effects upon the health and constitution of the tree. That it has such detrimental effects is, however, stoutly denied. It is asserted that the yield from a single half spiral or one broad V-cut is greatly superior to the yield from two cuts on the quarter system, and that trees tapped with a single V on half the trees keep a better shape, and the renewal of the bark appears to be better. It is indeed astonishing how the experience of one planter often appears to directly contradict that of others. I have heard many experienced planters state that with a broad V-cut the tree gets out of shape and bulges above the cut and towards the opposite side also. Yet able managers, after a considerable experience of this cut, make a directly opposite statement. They admit that theoretically the effects of such tapping ought to be bad for the tree, but consistently and persistently urge that this is not the case in actual working. One may find it hard to believe, but it may be so.

Several agricultural chemists have recently been testing sections of bark below areas severely tapped in order to ascertain what amount of starch is present in such areas. Starch of course means the food supplies which ought to be proceeding from the foliage above to the roots below, as well as nourishing the rest of the tree en route. It is instructive to know that in cases of severe tapping starch was found to be almost non-existent in many cases in the sections examined. I must say that I should like to know of such a test being made in the case of prolonged half spiral and broad V tappings, and if starch was then found to be present in normal quantities, it would go far to establish the claim made by these gentlemen that such tapping is not particularly injurious to the trees. So long as there is any doubt whatever on the matter, one would prefer what is obviously the less drastic system, the two cuts daily on the quarter section, despite the statement by these gentlemen that the yield is somewhat inferior; nevertheless, it gives what may be described as really satisfactory yields, and at the same time it should be less severe upon the trees. It should also be stated that the quarter section system with two cuts has advocates as stout and as experienced as those advocating the single half spiral or single broad V-cut. The best yields I know of are obtained on an estate which taps in this way.

The objection which some authorities take to the broad V-cut is that the point of the V drains continually and unduly from the same areas, and therefore they maintain yields cannot be so good. I confess that I have difficulty in appreciating the force of their argument. In any case practice is better than theory, and so far at least practice is against the theory, as the yields have been excellent and continue to be excellent.

Fine theories are sometimes dangerous things. I always prefer practical results to any theories, provided always that the practical results are attested by sufficiently long experience. As an example of theory against practice, I would refer you to what has occurred in the navigation of the air. Progress in this direction has been very largely due to the invention of what is known as the " gnome engine," fittingly so named because at first sight it seems to be of rather a freak type. In other engines the pistons revolve and the cylinders remain stationary. In this engine, however, it is the cylinders which revolve while the pistons are stationary. Owing to this revolution of the cylinders they are cooled by the air, and in this way one of the greatest difficulties experienced in the construction of a suitable light engine for flying has been surmounted. A great French scientist, after studying this engine, observed, " Of all types of engine this might be said to be in theory the worst imaginable, but in practice the best possible." The danger of laying too great a stress on theory as against practical results is thus obvious. The practical results of tapping experiments, if they have been carried on for a long enough period and have been carefully supervised, are better than any theories.

In all tapping experiments one ought to take a long view. It would not be wise to accept as final, results based upon any experimental tappings extending over a period of only two years. We all know that two years is not a sufficient time for the results of an imperfect system of tapping to fully manifest themselves. One can easily understand that excellent results might be forthcoming from the first two years basal tapping with half spiral and broad V-cuts, and yet the after results, tapping higher up, might be quite inferior. I do not assert that they would be inferior. As a matter of fact, I have been directly informed by some of the gentlemen in question that results from higher tappings with the broad V and half spiral cuts have also been excellent. These results, however, from higher tappings were not obtained after two years of tapping on the same system at the base of the trees, but after previous tappings on the quarter section system, and are, therefore, not quite conclusive. I only wish to show that the complete and final success of the broad V and half spiral systems of tapping is not yet absolutely demonstrated, as some imagine. For such absolute and final demonstration—if it is to be forthcoming—we shall have to wait longer.

With regard to the merits of daily tapping as against alternate day tapping, as you are aware, Mr. Morgan carried out a series of experiments on Bukit Rajah Estate. He personally watched over them—as he tells us—both in the field and in the factory, and, therefore, as he states, they ought to be of practical value. The results as summarised on page 14 of his book showed that, tapping on the half herring bone system, he obtained from the hundred trees he tapped daily an average return of 3.281 lbs. per tree. From the 100 trees he tapped on the same system every alternate day, he only obtained an average return of 1.94 lbs. per tree. So far, therefore, as regards Mr. Morgan's experiment, results speak for themselves. The trees tapped daily yielded 50% more rubber than those tapped on alternate days by the same system. Mr. Morgan points out that under both these systems " the trees were in a normal and healthy condition at the end of the experiments." Please note that I speak only of the yields of dry rubber. I do not think it wise to go into side issues and let our attention be distracted by small variations of the rubber contents of the latex. So long as yields of actual rubber are large and improving, and the trees in no way appear to suffer, variations of this sort may be largely ignored. If Mr. Morgan goes astray it is not in stating that the alternate day tapping yields nearly as much rubber per annum as daily tapping, but in leaving the impression, as I think he does, that the alternate day shaving is of only the same thickness as the shaving taken off when tapping is done daily. To assume this and to estimate on this assumption the results per unit of bark is a grievous error.

It has been used as an argument by those who favour alternate day tapping as against daily tapping, that Mr. Morgan on page 17 of his book makes the following statement :—

> " Of the other systems employing the half-herring bone on a quarter of the tree, that in which the trees were tapped on alternate days certainly gave the best results. Contrasting these figures with those of the same system tapped every day, it is not found that the latter (daily tapping) gives twice the volume of latex or twice the quantity of dry rubber. On the contrary, the yield of dry rubber per tapping is highest in the alternate day system than in the every day system."

Now if this statement is intelligently read, it is perfectly clear that while Mr. Morgan states that the yield of dry rubber per tapping is highest when tapping on alternate days, he does not for a moment state that the annual yield is greater by alternate day tapping than when tapping daily. On the contrary, he most explicitly and repeatedly states in his book that by daily tapping one gets 40 per cent. more rubber per annum than when tapping on alternate days. He is, therefore, not right in stating that the trees tapped on alternate days gave best results. Results can only be judged by total outputs over the year. I have to emphasize this, because I have found several people who have misunderstood the matter.

On the subject of daily tapping as against alternate day tapping, two of the best-known Federated Malay States planters have written :—

> "On our estates it has been found that the actual yield obtained each day of tapping from alternate day tapping is about the same as on the daily system. Experiments on some other places show that, making the best case possible for alternate day tapping, it will only give a yield of 240 lbs. of dry rubber as against 400 lbs. we obtain per acre from tapping daily."

After working out in full detail the apparent saving effected in recruiting, coolies' wages, and hospital charges, by alternate day tapping as against daily tapping, they show that the result would be that with 1,000 acres in bearing, a crop of 240,000 lbs. of dry rubber would be obtained by alternate day tapping, as against 400,000 lbs. per annum of dry rubber by daily tapping. The superintendence, the upkeep of buildings and several other charges would amount to as much money on the crop of 240,000 lbs. as on the crop of 400,000 lbs. The only savings effected would be that 125 fewer coolies would carry on the tapping, and the costs of recruiting these and their wages would be saved, with a proportion of hospital charges. After exhaustively reviewing all these items the result is announced to be that by adopting alternate day tapping there would be a loss of nearly £10 per acre, or on 1,000 acres approximately £10,000.

While emphasizing the present heavy financial losses sustained as the result of tapping on alternate days as against daily tapping, it is right to point out that it is just possible that after tapping on the alternate day system on one side of the trees for five or six years, the yields obtained might ultimately be as large as those obtained by daily tapping. There is no proof of this, but some strongly advocate it, and if it were ever proved to be correct, then alternate day tapping, employing as it would do only about 60% of the amount of labour on the tapping round, would in that case be ultimately much more advantageous than daily tapping. All the evidence is at present to the contrary, but the matter is well worth testing over a sufficiently long period. The period of these experiments should certainly be not less than four or five years if the experiments are to supply conclusive evidence. If the Rubber Growers' Association could arrange for a series of simultaneous experiments to finally determine the ultimate merits of daily tapping, alternate day tapping, and weekly tappings with the broad V-cut, the half spiral cut and the quarter section system, they would perform a service of the greatest value to rubber growers. Not only should the rubber yields be carefully noted in each case, and the effects on the trees, but the financial results in actual working of an estate should be made clear ; this is a matter of such vast importance to planters. If, from any cause, the price of rubber were to fall seriously, the settlement of this question might be the salvation of the industry. Had the Peradeniya experiments been really tapping experiments, we would have been in possession of most valuable information on this subject, but as it is, one can scarcely accept them as testimony. I most seriously commend the carrying out of such experiments as I have indicated to the consideration of the Rubber Growers' Association. An ordinary plantation manager would find it almost impossible to conduct the experiments properly over such a length of time or to give them the close supervision indispensable.

The experiments which Mr. Lock carried out in Ceylon at first sight apparently went to prove that by tapping only once a week the best yields of rubber were obtained at by far the lowest costs. Here are the results of an experiment made on an estate of which I am a Director.

Six separate lots of 100 similar trees each were set aside and tapped for one year. The result obtained from tapping 100 trees daily was 373½ lbs. of dry rubber. From tapping the second lot of 100 trees every alternate day, only 245½ lbs, of dry rubber were obtained. The third lot of 100 trees was tapped every third day and 150¼ lbs. of dry rubber were obtained. From the 100 trees tapped every fourth day, 124½ lbs. of dry rubber were obtained. From the 100 trees tapped every fifth day 87½ lbs. of dry rubber were obtained. Last of all, from the 100 trees tapped once every seventh day the yield was much the smallest, being only 50 lbs. of dry rubber. We thus see that in this particular instance, instead of the yields by tapping only once a week being equal to or superior to those obtained by daily tapping, they were less than one-seventh of the amount thus obtained. In every case, the less frequent the tapping the smaller the total amount obtained.

What might be the results if tapping only once a week was continued for four or five years, one can only guess. It would certainly involve very great present sacrifices of the rubber crop, and how far these would be compensated by larger future yields—if ever compensated—is an unsettled question. In this connection I ought to point out that not only were careful records kept of the yields from each system of tapping, but in order to note the effect on the trees careful records were kept of the girths of the trees in each case, and of any increase in circumference.

The results were as follows :—The average increase in girth of the 100 trees tapped daily was 3½ inches during the year ; the trees tapped on alternate days only increased 3·23 inches, a fact which would seem to indicate that the trees suffer more under alternate day tapping than under daily tapping, and therefore a fact full of interest. On the other hand, the 100 trees tapped only once a week increased in girth by no less than 4·15 inches. This would undoubtedly seem to prove that if one could afford to tap trees only once a week and pay one's way, the trees would be larger and better, and might, perhaps, when they were, say, over twenty years old—like the Peradeniya trees Mr. Lock experimented upon—give nearly as large yields with tappings only once a week as smaller trees tapped daily would give. I am sure, however, that not only could an estate not pay its way on such a production as the 50 lbs. per acre which we found to be the result of tapping once a week ; on the contrary, every pound of rubber would cost much more to produce than it realised in the market. One, therefore, if he proposes to go in for tapping once a week, would find it far better not to tap at all until the trees were at least, say, ten years of age. The benefits to the trees from the delay would be enormous. It may be, however, that even then the yields from daily tappings would still be five times greater than if the trees were tapped only once a week, and that Mr. Lock's experiments would receive no confirmation.

The Lock experiments have their values vitiated by the fact that, as was stated, " the system employed is one which is not recommended for practical estate work, as it was made rather drastic in order to test the endurance of the trees." This clearly shows that it was not a fair test of what the trees tapped daily would have yielded had they been properly used. With a reasonable system of tapping, the returns from the daily and alternate day tapping ought to have been twice or three times what they were. It has been pointed out that so drastic was the system employed that in the course of two years of the daily tapping all the bark had been removed to a height of six feet from the ground, and many of the trees tapped on alternate days also suffered severely, while the bark did not renew well. If the purpose, as stated, was "to test the endurance of the trees," all right, but in that case no attempt should be made to transmogrify the experiments into a just account of the yields obtained by different periods of frequency of tapping.

With regard to the number of cuts obtained per inch, there are often very serious misunderstandings. I have frequently been told by Managers and Assistants that they obtained as many as 30 cuts to the inch, but it was obvious that they were obtaining not more than 18 to 20. I have gathered shavings at the factory and from under the trees and reconstructed an inch of these, and was able to such occasions to demonstrate that not more than the above mentioned number of cuts could possibly have been obtained. I do not think that there are any estates where the tapping is done to such perfection that anything like an average of 30 cuts to the inch is obtained by the coolie force. No doubt on every estate there are some specially expert and careful coolies whose work is excellent and these help to fix the standard of the force. It will, however, be readily understood that the larger portion of the coolie tapping force is more apt to be careless and indifferent than careful, and supervision has to be scrupulous and continuous if the work is to be kept up to a good standard. On a well-managed estate 20 cuts to the inch may be taken as a fair average, 18 cuts to the inch are not at all uncommon, and I am satisfied that the number of estates where the average is nearer 16 is not so very small. Every coolie ought to be made to gather his own shavings and to bring them into the factory, where they should be examined with regularity either by the Manager or by one of the Assistants. Not only should the shavings be examined when brought to the factory, but the tapping assistant ought to continually scrutinize them at the trees where tapping operations are being carried out; otherwise, when a check is maintained, the wily coolie is apt to throw out the thicker shavings and bring only to the factory those which are moderately thin. If sections of bark are laid out to last for a certain period calculated upon not less than 20 cuts to the inch being obtained, and if only 16 have been obtained in actual practice, then bark areas become too quickly exhausted, new bark is tapped before it is properly renewed, and over-tapping and disorganization inevitably follow, to the surprise and disgust of the management. In order to get thin shavings it is of course absolutely essential that all tapping tools should be kept well sharpened and in good order. With alternate day or even less frequent tapping, the saving of bark as against daily tapping is quite delusive. Very many managers and assistants have assured me that they observed when they experimented for a period with alternate day tapping as against daily tapping they had, in the case where tapping was done on alternate days, to take off very much thicker shavings than when daily tapping was in progress. This is a point generally lost sight of. Another cause which upsets the schemes whereby bark is to last for a certain period, is that tapping is frequently conducted during periods of drought. When the weather has been dry for a long time the flow of latex is poor, and the coolies are apt to cut thicker shavings in the endeavour to get an average return of latex. This means fewer cuts to the inch and an earlier finish up of the sections of bark than calculated on.

There is no doubt that when trees have been severely tapped for a long period the constitution of the tree is considerablv weakened. Such trees are much more liable to attack from disease, and were it possible to obtain correct figures from many of the older estates which formerly gave high yields per acre, one would find that in many cases the mortality among the trees has been excessive. Personally, I know of one estate where the mortality must have been enormous. I scarcely like to give the figure, but am certain it must have been at least 50% of the old trees. Apart from the question of mortality and liability to disease, when one enquires carefully into the yields of certain estates which were formerly reported as giving 400 to 500 lbs. per acre, and even larger amounts, one learns that these estates have now gone back to a normal figure, and are content if they obtain an average return of 300 lbs. per acre. The management have perceived the folly of over-tapping trees ; they have found that these large yields have to be paid for later on by non-renewal of the bark, and generally bad condition of the trees, and I am informed in certain quarters that they now deprecate the local management obtaining excessive yields per acre. No doubt many may dissent from this view, but I am confident it is correct, and I have the support of the best informed authorities in plantation management in favour of such a view.

Whether trees are severely or lightly tapped it is very advisable to rest them for, say, a month during a period of severe drought, or when the trees are wintering. It is true that this appears to involve a sacrifice, but the increased yield which the trees give after the rest, brings up the total amount for the year to quite the figure which would otherwise have been obtained when the trees are preserved in better health. It is not a sound policy to tap trees when their constitution is weakened in wintering. Of course the question which arises is, how is the tapping force of coolies to be employed, and having consulted with various V. A.'s on this subject, they inform me that they do not see any great difficulty on this point, that some work can always be put in, and there is no reason why the labour force should be idle.

I should not like it to be assumed that in the systems of tapping mentioned there is anything in the way of finality. We may hear any day of some new method or modification of the foregoing systems which experience may show to be a distinct improvement. All that is claimed is that, so far as present knowledge extends, the three methods, single half spiral, single broad V-cut or two cuts on quarter section with daily tapping, seem, taking the broad view of all the circumstances, to be the most suitable in the present stage of the rubber plantation industry. My own opinion is that the quarter section system is the safest and the best.

In the future, as during recent years, I hope we shall be always learning and always ready to learn something new and anything better. The book of knowledge is not closed. The intimate secrets of Nature have yet to be wrested from her.

Dr. STEVENS : I notice that there are two or three very able planters here who should be able to make some helpful contributions to a discussion, but before they do so I should like to put one or two points in connection with this most able summary and criticism of tapping methods that Mr. Maclaren has given us. The first point has regard to the apparent discrepancy between theory and practice in connection with the broad V or the half-spiral method. The first experiments were made by Keating (?)

It has been the custom in following these earliest experiments to cut from the top. In a properly tapped tree there should always be a continuous thin active layer of bark cortex left which is able to carry on the function in the normal manner. Concerning tapping experiments there are two or three words I want to refer to, which call for remark. I think everybody will agree that tapping experiments on which you can rely are some of the most difficult experiments that can well be imagined. In the first instance many have been made on trees which had previously been tapped by some other system. I think that greatly influences the result. The previous tapping history of a tree does undoubtedly influence the yields obtained in the next six or twelve months, and I believe it does so even after a couple of years. Experiments should be made on trees which have not previously been tapped. That was the case, I know, in connection with the experiments made by Mr. Morgan, now some seven years ago, which have been referred to in the paper. Then another very important point, perhaps more important still, is the time of day at which the trees are tapped. In some experiments an area has been divided off, and batches of trees have been tapped in a different manner, but it has been the habit, perhaps, for one or two coolies to do all that work. The yield obtained, I understand, depends very much on the time in the day that the tree is tapped, the earlier in the day the better. Consequently, in experiments which are not to be open to criticism it is necessary that your blocks of trees should be tapped at the same time in the morning. A further point with regard to the advantages of tapping every day or on alternate days is that it depends somewhat on the system of tapping and the number of cuts made. The results that Mr. Maclaren has mentioned, of experiments made on one of his estates, are very interesting, and I hope he will give full details of them.

Mr. C. H. Golledge : I presume that in these experiments the scrap has been carefully weighed up in each case ; not only the first latex, but also the scrap. In connection with his references to the half-spiral method of tapping, will Mr. Maclaren demonstrate to us what he determines as left to right. I think the half-spiral to which he refers is generally outlined to the left of the channel, but it is obvious that it might be in either way. The ridge to which he drew attention, which appears down the channel of the tree in the broad V cut, is due to the sudden cleaning of the channel and the damage done by the tapping tube. It is a growth due to the wounding of the wood in most cases. Of course, when Mr. Maclaren refers to the lower grades of rubber he is dealing with what we know as the lower grades now, those for which we get less when placed on the market, but whether they will ultimately be the lower grades I think very questionable. In fact, from what we have heard from the manufacturers it is really a better rubber than the rubber that constitutes our first grade. On the question of the frequency of tapping, perhaps Mr. Maclaren will be surprised to learn that, tapping every three days over an estate of 1,000 acres, with trees which were of various ages, and which had been planted in the years from 1903 to 1907, the figures that I can show him give a crop of 350 lbs. per acre or over, in some cases going up to 400 lbs. and 500 lbs. and even more for the acre. We therefore must not accept his figure of 150 lbs. to the acre for third day tapping as general, or as an average.

Mr. de Bois Maclaren : Even taking the length of my paper into consideration, I feel sure that you will think there are many matters that have been neglected. In a paper such as that, intended to be read publicly, there is certain information which I cannot give, but which I shall be very glad to give privately to gentlemen interested if they should desire it. Of course, Dr. Stevens takes a very deep interest in all matters connected with rubber. He is entirely right in stating that experiments should be made under precisely the same conditions for all trees. It would never do for a moment if some were tapped early in the day and others came in for their turn later. In fact, that is the trouble with experiments carried on by managers and assistants. It is a real necessity for us for the Rubber Growers' Association to send out a competent body not only to carry out scientific experiments with scrupulous care, but to carry them on for a sufficiently lengthy period. This is absolutely necessary. We have had no thorough and complete demonstration to the satisfaction of the planters of what is the best system of tapping; nor have we any thorough and complete demonstration as to what will give the best yields in the future. We only know what is giving the best yields at present, and that is daily tapping. Whether ultimately alternate day tapping will give the best results, or weekly in older trees, I do not know. At present it seems to me that everyday tapping is the course that pays best. In reply to the remarks by Mr. Golledge, scrap ought necessarily to be weighed in, in each case. The half-spiral is just the one cut.

Mr. GOLLEDGE: To the left or the right of the channel?

Mr. DE BOIS MACLAREN: Some people would have it one way, and some to the other.

Mr. GOLLEDGE: I do not quite follow you.

Mr. DE BOIS MACLAREN: With regard to the formation of ridges in the channel, I have heard various accounts as to how this is brought about. The ridge complained of is generally due to the coolie suddenly cleaning out the channel and some damage being done thereby. It is apparently a growth due to the damage; an exposure of the cambium.

Mr. GOLLEDGE: When Mr. Maclaren refers to the method of cutting, there is a special claim, not for the cut that Mr. Maclaren just illustrated, which would be to the right of the channel, but for one which would be exactly opposite, to the left of the channel.

Mr. DE BOIS MACLAREN: If Mr. Golledge would like to have a statement privately I would be glad to show him what I mean. There are so many other papers coming on.

Notes on the Physiology of the Latex Production in Hevea.

By

R. H. LOCK, Sc.D., F.L.S.

MR. P. J. BURGESS presided in the absence of Dr. Torrey through indisposition.

DR. LOCK: I propose this afternoon to give a short account of a remarkable complex of minute vessels—the laticiferous system—which has attained to a vast commercial importance on account of the chemical composition of the milky fluid, or latex, which it contains. Few vegetable structures can compare with the latex vessels of Hevea in the interest which they may reasonably excite in the minds of economic botanists: Some understanding of the physiology of latex formation is desirable on the part of all who are in any way concerned with industries connected with rubber. I feel therefore that my subject in itself needs no apology on an occasion like the present. On behalf of botanists generally some apology is perhaps appropriate on account of the very little which is accurately known about the functions and formation of latex. The fact is that there is really less to be said about what we do know than about what we should like to know. And as in the past a large proportion of our knowledge of the laticiferous system has been derived from practical experiments in tapping and in the commercial treatment of the latex after its removal from the tree, so in the future we look to the co-operation of practical planters for carrying out those extended experiments which are required if our knowledge of these processes is ever to become in any way complete.

I shall presently have something to say about past, present and future methods of tapping; but it will be best, I think, to begin with some reference to the structure and arrangement of the laticiferous system as it occurs in the bark of Hevea. Time will not admit of more than a passing reference to the unsegmented latex tubes of such plants as *Castilloa*, the Mexican rubber tree, and *Funtumia* the rubber tree of West and Central Africa. In these trees, and indeed in the vast majority of latex-containing plants, the laticiferous system is derived from a small number of original tubular cells, which grow and branch copiously, insinuating themselves between the cells of the cortex or inner bark, as the dimensions of the plant increase. It so happens that the latex vessels of the two most important rubber-producing trees—*Manihot*, the Ceara rubber tree, and *Hevea* itself—are constructed on a different pattern and arise in a different way. The description which I shall now try to give relates especially to the development of the laticiferous system in the trunk of *Hevea brasiliensis*.

The growth of a tree in thickness is initiated and mainly located in a thin cylindrical layer of delicate tissue, known as the cambium, situated between the wood and the bast or inner bark. This layer is made up of very delicate more or less brick-shaped cells, which undergo repeated division and thus contribute additional structural elements to the tissues within and without. We are concerned at present exclusively with the latter, namely with the cells which are continually being added to the inner side of the bark. It is necessary to allude briefly to the general structure of the bark, a term which we may apply conveniently, if not altogether accurately, to the whole body of material lying externally to the wood and the cambium. With a similar disregard of the more rigid botanical terminology, we may discriminate between an inner and an outer bark. The outer bark is hard and resistent. It includes layers of cork and other substances, which probably exercise a purely protective function. We shall confine our further attention to the inner portions of the bark where the fluid latex is situated. The inner bark of the great majority of trees may be described as woven out of interlacing strands of minute cells. Some of these strands—the medullary rays—run in a radial direction, and correspond closely with similar strands which occupy a like position in the wood, and radiate outwards from the centre of the tree. The remaining elements of the bark, including the latex vessels, are arranged in longitudinal strands and occupy the intervening spaces between the medullary rays. If we imagine a series of closed cylinders of netting—the image is due to Mr. T. Petch—placed one within the other so that the meshes accurately coincide, we shall get a rough representation of the arrangement of the longitudinal elements. This simile will be made more realistic if the nets are compressed so as to elongate the meshes in the direction of the length of the stem. We may further imagine that our networks are of different materials, some of metal and some of cord; the former, representing latex networks, are considerably less numerous than the latter, which would represent the remaining longitudinal elements of the inner bark. In order to pursue realism a step further we ought to construct our metal network not of wire but of very fine tubing, accurately fitted together so that the lumina of the tubes are continuous throughout the network. In order to make the image still more complete we may give the whole series of networks a slight spiral twist, so that the longer axes of the meshes slant upward to the right, being inclined to the vertical at an angle of about twenty degrees. The strands of the laticiferous network are not solid cords, but are tubular, and the tubes communicate freely at the nodes of the network. This applies not only to the laticiferous networks but to much of the intervening tissue as well. Adjoining networks contain the vessels which conduct the food supplies of the tree in a longitudinal direction. These vessels and the latex vessels may lie side by side in actual contact. The latex vessels are also in contact with the medullary rays, the cells of which are engaged both in the storage and in the transference of food materials. It is therefore clear that the laticiferous system is situated in a position eminently convenient for drawing upon either of these supplies of food.

In the earliest stages of their development, as seen close to the cambium, the latex vessels are built up of longitudinal rows of separate brick-shaped cells. The tubular structure is subsequently arrived at by the breaking down of the intervening cell walls, leading ultimately to practically free communication throughout the whole of each network. Between adjoining networks on the other hand, no communication whatever has yet been observed. It is apparently possible for a free circulation of the contents to take place throughout the interior of any single network. Owing to the minute size of the tubes such movement must, however, be very slow even in the direction of the length of the tree. In the transverse direction round the tree, movement, though still possible, must be several times as slow as in the vertical direction. In order to cover a horizontal distance of one inch in the bark the latex would have to travel an actual distance of five or six inches in a zigzag fashion, on account of the elongated shape of the meshes of the latex network. Circulation is also impeded to some extent in the younger vessels by the remains of the cell-walls which originally divided up the tubes into separate compartments. In the youngest vessels of all, circulation is still effectively prevented by the presence of these dividing walls. This is the case at a stage when the component cells of the system already contain substances which agree with the normal contents of the older vessels in their microchemical reactions.

The last named fact is one of many which points to the origin of the latex in the laticiferous tubes themselves. It has been suggested that the latex tubes function simply as channels for the conduction of the latex from its source in the leaves or elsewhere. I believe on the contrary that the laticiferous tissue of the bark itself is the site of the formation of latex. It may perhaps be suggested that the cortical cells which adjoin the latex vessels play an auxiliary part in this important function. In sections of very young latex vessels, long before the breaking down of the walls which separate their component cells, the nuclei of adjacent cortical cells may often be seen pressed closely against the side nearest to the adjoining latex vessel. Now nuclei are generally regarded as bodies which govern the activity of the cell contents—the brains, as it were, of the cells themselves. The characteristic position of the nuclei which I have described is to be observed at a stage when the contents of the latex vessels are just beginning to show the characteristic stain which indicates that they contain caoutchouc or some closely allied substance. The suggestion arises that these neighbouring cells are assisting in the formation of the characteristic cell contents of the latex vessels, perhaps by handing over to them the necessary raw materials for the construction of indiarubber. This is of course merely a suggestion. Further evidence upon the question of the origin of the latex is derived from tapping experiments. Before passing on to these I should like to say a few words about the possible functions of rubber in the tree. Or since the presence of true rubber in the living latex is a point still open to controversy, perhaps I ought to say the function of the substances from which rubber is derived on the coagulation of the latex.

Supporters of the Darwinian theory are more or less bound to suppose that the elaborate system of vessels containing the latex could not have been independently evolved in a number of different families of plants without serving some purpose useful to the individuals in which it appeared. The functions which have been ascribed to latex are however largely a matter of guesswork. Almost every writer upon the subject has favoured a separate theory of his own. The functions suggested have included the storage or conduction of food materials, of excretory products and of water, or a combination of any two or more of these uses. I do not propose to put forward any new theory of my own, but only to record my personal impression that the function of protection from the attacks of insect enemies is the only one which seems to rest on any solid foundation. Almost all trees contain some substance detrimental to burrowing insects. As regards *Hevea* I can only say that if I were a beetle I should regard the bark—in the absence of latex—as an almost ideal material for boring holes in.

In different kinds of plants the composition of the substance known as latex varies very widely. Only a few of the numerous plants which contain latex have developed a sufficient proportion of caoutchouc to render the extraction of the rubber a profitable undertaking. In *Hevea* the actual rubber may amount to nearly fifty per cent. of the weight of the latex, and may make up as much as 98 per cent. of the total solids present. The evolution of such a latex as this seems quite inexplicable except upon the supposition that in past ages a beneficent Nature was able to foresee the present development of the trade in motor cars and golf balls. In other words the evolution of the latex of *Hevea* is to my mind a complete mystery on any of the current theories of organic transformation. Latex as it flows from the tree is of course not quite identical with the actual contents of the latex vessels. Other cells besides the laticiferous members are necessarily cut through in tapping and a small proportion of their contents is added to the general outflow. Consequently, even if the latex itself were purely a product of excretion—a supposition which appears eminently doubtful—there could be no doubt that the fluid drawn off in tapping would constitute a serious tax on the resources of the tree. The removal of bark in paring is a serious loss which has to be repaired at the cost of much food and energy, but the removal of latex is a further and probably much greater tax, drawing as it does upon areas which extend considerably beyond the region actually under operation.

A good deal of attention has been drawn to the work of Fitting upon the depletion of food supplies in the bark as the result of tapping. Experiments carried out by the Department of Agriculture of the Federated Malay States do not entirely confirm Fitting's conclusions. The Malayan observations show, as might be expected, that the quantity of food supplies stored in the bark varies considerably according to the season even in untapped trees. The fall of the leaves, characteristic of the wintering period, is followed by a marked diminution in the stores of reserve material. Experiments made in Ceylon showed that the fall of the leaves was followed by a reduction both in the quantity and in the concentration of the latex extracted from the trees. The subject of food supplies in relation to tapping is probably worthy of still more minute study than it has yet received. It can scarcely be denied however that tapping leads to a serious tax on the resources of the tree and that amongst other results heavy tapping leads to a reduction in the rate of growth, to a diminution in the crop of seed, to a reduced proportion of rubber in the latex extracted, and finally, if persisted in, to a failure in the proper renewal of the all-important bark.

One further point before we pass on to the actual evidence of experiments in tapping. What ultimately happens to the rubber in an old tree which has never undergone the operation of tapping? As we pass outwards and away from the youngest portions of the bark the latex vessels become more widely separated from one another owing to the further development of the intervening tissue. Finally they disappear entirely. Their contents dry up and their cavities are encroached upon by the growth of stone cells and other hard protective tissues. It is exceedingly difficult to follow the exact fate of the latex vessels microscopically, but traces of dry coagulated rubber occur scattered through the external parts of the bark, where they are finally cut off by layers of impervious cork cells, and the tissues which contain them scale off at last from the surface of the tree. There is no evidence that the rubber contained in the outer latex vessels is reabsorbed in any form, and the probabilities appear to be against this taking place. There would therefore appear to be from the planters point of view a waste of rubber in the case of a tree which is left untapped until a late period of its development, quite apart from any stimulating effect which tapping may have upon the normal rate of formation of caoutchouc. It would therefore appear, for this reason only, to be unprofitable to leave a tree untapped for a protracted period, in the hope of obtaining larger supplies of rubber later on.

We may now proceed to examine some of the evidence, bearing upon the physiological functions of the laticiferous system, derived from experiments in tapping the trees. As regards methods of tapping we shall confine ourselves entirely to the methods of paring or excision. Methods of incision are still under trial, and there is much to be said for some of them—at least theoretically. So far as I am aware however, almost all the experiments of which satisfactory records are available have been carried out by one or another method of paring. The technique of paring the bark is probably sufficiently familiar to all present and need not be further particularised. At the present day to all intents and purposes the methods are everywhere the same, although a variety of different tools is used, whilst the pattern marked out upon the bark varies in different plantations. The first and one of the most important points brought to light by tapping experiments is what was formerly known as wound response, but would perhaps better be described as continuity of yield. When tapped by any ordinary system at any interval between one and ten days, or sometimes even longer, a *Hevea* tree shows as a rule a slight increase in yield during the first few tappings. Afterwards the tree continues to yield latex at a more or less steady rate, which is, however, subject to seasonal variation, and is also affected by the method and rate of tapping and by a number of external factors which include climatic conditions, the nature of the soil, water supply and the like. If tapping is begun on a young tree, say in its fifth year, on a strictly moderate system, which we may provisionally define as one which allows five or six years for the renewal of the bark, the yield will as a rule go on steadily increasing year after year for an unknown term of years. The production of latex will continue, apparently indefinitely, although the tree is tapped every day without any interval of rest. It is this faculty, combined with the remarkably favourable consistency of the bark for tapping operations, which gives to *Hevea* its outstanding position among rubber producing trees. Of its competitors *Manihot*, which exhibits a similar continuity of yield, is more difficult to tap and gives a smaller output of rubber, whilst in *Funtumia* and *Castilloa* there is no continuity of yield, and an interval of some months must intervene between successive tappings.

With strictly moderate tapping no limit can yet be put to the continually increasing output of latex and of rubber. Unfortunately we cannot even yet define with any certainty what constitutes moderate tapping. The question of the optimum rate of tapping is the crucial problem affecting all plantation practice, and no one will pretend that this problem is yet completely solved. We know that in the past tapping has often been unduly severe, and this excessive tapping has led in many cases to a marked diminution of yield as time went on, or has even made it necessary to discontinue tapping for want of renewed bark of suitable thickness. In some cases no doubt this severe tapping has been justified from a commercial standpoint by the high price of rubber recently prevailing. He would be a bold man who would now venture to foretell the price of rubber at any future date, but I think we may reasonably expect the fluctuations in value to be considerably less during the next ten years than during the past ten. If this be so, any evidence bearing upon what we may call the optimum rate of tapping will have not only a scientific interest but also a high commercial value. By the optimum rate of tapping I mean for any given tree the system which will yield in the long run—say in fifty years—the largest yield of rubber without leading to premature debility. The problem is complicated by a large number of external factors a few of which I may briefly enumerate without attempting to discuss them at any length. It will then be necessary to put these factors aside and to discuss the question of an average tree growing under average conditions. Climate, soil, rainfall and elevation must all be expected to affect the optimum rate of tapping. Experiments carried out, for example, at an elevation of 1,500 feet in Ceylon can be expected to have only a very limited application to the case of a plantation situated near sea level in the Malay Peninsula. It is generally stated that the rate of renewal of the bark can be considerably accelerated by the application of artificial fertilizers. Renewal of the bark is not the sole criterion of successful tapping, although it is one of the readiest tests of success. But the optimum rate of tapping in a plantation in which careful attention is paid to cultivation and manuring will clearly be different from the optimum rate in a plantation in which the trees are left to grow in a more or less natural condition. The distance between the trees and the age at which tapping is first begun are two other factors of great importance, whilst since trees vary enormously among themselves in vigour and yielding capacity, we can at the best of times only adapt our methods to the needs of the average tree if, as is in practice necessary, we are to lay down a system to be applied to the whole of a particular plantation. In fact in order to be on the safe side, it will be best to concentrate our attention on the needs of a tree which is slightly below the average in its powers of endurance. In other words we find it advantageous to wait until such a time that the whole of the trees on a given area can be put on the same system even though they vary considerably in size.

What do we know about the optimum rate of tapping of an average tree, say in the low country of Ceylon subject to an annual rainfall of about 90 inches ? We may be pretty sure that a few years ago trees were being tapped very nearly up to the supposed limit of their permanent capacity. It is also certain that for some years past there has been a tendency, as the result of experience, towards a steady reduction in the severity of tapping as compared with the methods formerly thought to be suitable for permanent employment. This tendency is manifested in a reduction both of the length and the frequency of the tapping cuts, with the result that a single cut, either V shaped or simply slanting, is becoming increasingly popular. The same tendency is shown in the length of the period recommended by experts as necessary for renewal ; and it may be recorded to the credit of the experts that their recommendations have always favoured a longer period than the prevailing practice. A few years ago three years was considered sufficient for the renewal of the bark, the other day it was four years, and already we are beginning to consider whether it should be five, six or eight years. Of course when we speak of bark renewal in this way, we are really thinking of something more than the development of a sufficient thickness of renewed bark to allow of the passage of the tapping knife. What we have under consideration is, as a matter of fact, the principle which I have described as the optimum rate of tapping.

It is certainly a surprising fact, but one which now seems to be endorsed by general experience, that after a certain time the yield of rubber is scarcely diminished by reducing the number of cuts from three or four to two or even one of equal length in the case of young trees. There are, however, certain disadvantages associated with the reduction of the tapping cuts in length and number beyond a certain point. The chief of these is that the reduction in the number of cuts does not lead to an economy of labour in any way commensurate with the reduction in the actual amount of paring carried out. We should probably get a very much greater saving of labour if we set about reducing the severity of tapping in another way, namely, by increasing the interval between successive tappings. It is clear that only half the amount of labour is required for tapping a given number of trees by the same system on alternate days as compared with daily tapping. By reducing the number of cuts from two to one the expenses are not reduced in anything like the same proportion.

Theory is all in favour of the method of increased intervals. So far as I can gather, the result of practical experience is more or less equally balanced. But it is doubtful whether the method has ever really had a fair trial. The experiment has been made in a number of instances of changing from daily to alternate day tapping for a period of three months, without any other alteration of the tapping system, and the result was far from being proved a loss in all cases. But the result of such a trial could not in any case be regarded as conclusive. A very much longer experience was required to show the advantage of a reduction in the number of tapping cuts. Experiments carried out by the Ceylon Botanical Department on old and closely planted trees at Heneratgoda appeared to show that just as reduction in the number of cuts leads to little or no diminution of yield in the long run, so the same thing happens if the original number of cuts is retained and the interval between successive tappings increased. The experiments require repetition and extension, but I would emphasise the fact that for a fair trial we ought to go far beyond alternate day tapping. Just as success has been attained by reducing the number of cuts to one, whereas in the early days as many as six or more were often used ; so we ought to try increasing the interval up to as many as six days or more. The experiment also requires to be made in another way, namely by making the rate of removal of the bark the same in all the series. Thus we might tap daily with one cut, on alternate days with two cuts, at three day intervals with three cuts, and so on up to once a week with seven cuts, on a system which allows at least six years for bark renewal. And the result of the experiments should include a careful record of the cost of tapping in each case. Unfortunately we shall have to wait many years for really conclusive results.

The problem of the optimum rate of tapping is one which can only be solved experimentally. All plantation work may however be looked upon as so many experiments leading in the direction of its solution, and every year brings us nearer to the ideal method. Nevertheless more definitely planned experiments, to be carried out without special regard to immediate profit, are very desirable.

It is curious that so far as I am aware hardly any definite experiments have been made with a view to finding out the optimum age for beginning tapping. We know that a tree may be tapped with apparently complete success from the fourth or fifth year onward. But how would the yield in fifty years compare with that which would be obtained supposing the commencement of tapping were delayed for one or two more years ? A few year's work would probably give some indication of the answer to this question. The experiment is a perfectly simple one and certainly ought to be made.

I should like to conclude with one or two other results obtained from tapping experiments. The first is the very high individual variability of *Hevea* in respect of yield. In a block of one hundred trees it is not at all uncommon to find the best tree giving twenty times as much latex as the worst. Generally speaking no doubt the largest trees yield the most latex, but one tree will often yield ten times as much as another of the same circumference. The difference is so great as to render it highly important—should it be decided to thin out a plantation—to keep all the best yielding trees and to remove the worst quite regardless of position. The final arrangement of the trees will no doubt be very irregular, but there is no evidence that this is a serious disadvantage. Certainly there is no disadvantage at all comparable with the loss involved by taking out alternate trees regardless of their yielding capacity. This great variation in yield also promises well for the result of seed selection with a view to the production of a uniformly high yielding strain of *Hevea*. Such selection is however a decidedly lengthy process.

I think (added Dr. Lock) the matter it will probably interest this meeting to discuss as much as any other is the question of interval in tapping, and the possibility of getting some clearer ideas as to the advantages or disadvantages of increasing the period, which from a botanist's point of view—I do not claim to be a practical man—theoretically seems the right thing.

The CHAIRMAN : I think you will all agree that this is a most interesting paper. Dr. Lock has raised a large number of questions which are controversial, and has also given us a very clear account of the physiology and structure of the *Hevea*, which we are all glad to have heard. There are, as he finished his paper by saying, one or two outstanding points which will probably absorb discussion. One is as to whether the output is going to be progressive and the other the question as to whether alternate day tapping, more frequent tapping or varying tapping will be best, and likewise as to the number of cuts which will be the more commercial. On the subject of the progressive yield, I would like to have information as to whether the output is going to be progressive per unit length of cut, or whether it is due simply to the area of bark available per acre. As the trees become fewer there must be a limit to the area of bark per acre. The questions of alternate day tapping as opposed to daily tapping, tapping at more frequent or less frequent intervals, and the tapping of large or lesser surfaces of bark, I will leave to more practical people. I would like to raise this one point, however, that if daily tapping is resorted to the thickness of the paring has advantages when compared with cases in which three or four days are permitted to elapse, simply because of the hardening of young scrap which is left in the bark, rendering it more difficult for the coolies, where there are greater intervals, to tap as large a number of trees. I think we should all look for an expression of opinion on these points from any practical planter who is here now.

Mr. G. H. GOLLEDGE : Dr. Lock has stated the case so clearly both from the planter's and the scientist's point of view that if we waited here and discussed the matter all night we could not get a more definite conclusion. We can only proceed by the experiments which are being made continually and we look forward to the results which will be obtained. With regard to the time that should be allowed to elapse between tappings, I have always firmly believed that third day tapping is the best, and have carried on that system. I do not think that this prolonging of the time between the cuts at all affects the number of trees which can be operated on by the coolie, because the scrap is mostly collected by special labour.

Mr. W. T. Gibson : Has Dr. Lock ever, in any of his microscopical observations, discovered anything to lead him to a conclusion as to the situation in which the caoutchouc is actually formed, whether it is in the lining of the laticiferous vessels or in the latex itself in the vessels ? I mean that some raw material exists in the latex which some ferments in the locality change to caoutchouc. The first idea is the one that it is more usual to believe. When we draw an analogy with ordinary secretory cells, we are inclined to believe the caoutchouc is formed in cells lining the laticiferous vessels. That leads to another point. Has Dr. Lock observed the presence of the cells lining the laticiferous vessels after the channel has been formed which contains the latex ? Do the original cells persist ? That the transverse walls do not entirely break down is a possible explanation of the fact that when you first tap *Hevea* you do not get such a big output as you would do from *Castilloa*. That does not seem very probable, however, because in *Manihot* there is the same imperfect perforation of the transverse walls, and you do not get wound response there. If in *Hevea* there is imperfect perforation of the transverse walls it may hinder the flow at first, but it really merely holds back the flow of latex which will appear at the second tapping. In the case of *Castilloa*, where there will be no hindering of the flow of the latex in that way, you get a big flow at first which exhausts the vessels, comparatively speaking. Therefore you cannot get big flows later.

Dr. Lock : In *Manihot* surely you do get something that corresponds. You can tap every day or every other day.

Mr. Gibson : I was not aware of that. I have searched for the information. I know the trees are tapped very frequently, but the question is, what is the actual amount they get in subsequent tappings. Is the flow in the later tappings much less than in the first, or is it greater.

Dr. Lock : I think it is on somewhat the same lines as with *Hevea*, but I do not know of any good records.

Mr. Gibson : With regard to the function of latex, Dr. Lock gives his preference to the hypothesis that the latex protects against the attacks of insects. But there are two objections to that, one being that the laticiferous vessels are found in the wood in some trees, while secondly, in the *Guayule* there are no laticiferous vessels, and the caoutchouc globules are scattered through various cells. In that case it is hardly possible that the caoutchouc could protect against the attacks of insects.

Mr. H. Hamel Smith : Perhaps the protein might go to nourish the tree, and the gummy part might keep out the insects. *Guayule* is an entirely different tree from *Hevea*, and Nature may have had altogether different reasons for giving the latex in the way she has chosen. I wish to say a word on the subject of progressive output. I have not been out in the tropics for some time, but I am interested in a *Ceara* company in East Africa. I am sorry to say that as far as I can see on paper the yields are not increasing. Although we have not been told that the trees are not still giving the same amount of flow it does not appear that the amount of rubber coming on the market has increased. I think it should have done so. As I believe our manager out there is a trustworthy man, I take it that the dry seasons may have affected the output of trees, I would like to know the percentage of rubber in *Ceara* latex.

Dr. Lock : With regard to the question of a progressive output, I was referring to an individual tree. There is no doubt that you should be able to devise a system of tapping in which a single tree would improve its yield steadily up to say fifty years. We want to get the rate of tapping which will give in the whole fifty years or more the largest amount of rubber. That would be the ideal method. With regard to the microscopical examination of bark, the specimens were preserved in a solution the active property of which was osmic acid. That stains the contents of latex vessels. The appearance is practically identical at all stages. As regards the question of secretion, there is this point, that you do have these characteristics in the contents of the very youngest cells of all. It is clearly at that stage an internal secretion inside the cell. I am afraid I have no observations worth mentioning as to whether after the walls are broken down the cells adjoining the tubes are secretory cells.

Mr. GIBSON: Of course I do not mean the cells outside the tube. I meant the protoplasm belonging to the cells which give origin to the laticiferous vessels.

Dr. LOCK: That is, the lining of the cell itself.

Mr. GIBSON: Does it persist and keep the supply of latex going? That is the point.

Dr. LOCK: It is difficult to say how long it persists. I think at this stage, when the tubes are becoming continuous, you can recognise the lining of the latex tubes.

Dr. SLOCUM: Has any observation ever been made that a latex tube after once being drained of latex has ever been filled again with latex?

Dr. LOCK: That is an alternative suggestion, but I do not know of any microscopical observations to prove it. I think the amount of latex you get in a year's tapping is often larger than the amount which the tubes can contain at any one time. Meanwhile a certain number of tubes are formed. It is a matter of reckoning, but I think it apparently works out that way. The total amount of rubber you get from a tree in four or five years may be very striking.

Sir HENRY BLAKE: Has any observation ever been made to answer the question whether any other portion of the tree except the latex producing portion does produce rubber, that is to say, apart from the latex-bearing tubes? You will remember that the Germans at one time went in for macerating the young tree—the whole tree. Whether it succeeded I do not know. I was at the time in Ceylon. They were trying the system of taking up the young tree when about two years of age, macerating the whole tree, and replanting. Whether they thought it possible that there might be rubber in other parts of the tree I do not know.

Dr. LOCK: A gentleman mentioned just now that *Guayule* contains the latex scattered throughout the plant, but I think in such trees as *Hevea* it is all found in the tubes. Dealing with the matter of the flow of latex in *Castilloa* and in *Hevea*, the tubes in *Castilloa* are very much larger. You would imagine that the flow would be very free. I think it is just a question of the time the flow can go on before coagulation sets in on the surface.

Mr. H. HAMEL SMITH: The rubber content of *Castilloa* is comparatively small.

Dr. LOCK: You get a much bigger flow at one time, but have to wait for the second tapping for several months.

Observations on and Comparative Tests of the Latex of Wild and Plantation Hevea.

By

FELIX RIPEAU.

The favourable reception given to plantation rubber by the manufacturers on its first appearance led the producers to believe that they had arrived at the best results at the first start. The superior prices obtained by plantation rubber over that of the Amazon were, *a priori*, sufficient to justify this belief and thus lull the activity of the planters instead of urging them towards the search after possible improvements. Later, when the manufacturers had become convinced by practice that Para rubber was after all superior to plantation products, the market price of the latter began to drop, and is now lower than that of Para rubber; moreover, without taking into consideration the difference in the published market prices it is sufficient to assert that Para rubber would be at least 18% more valuable than it is if it were exported in thin dry sheets instead of in the balls (graded or not) in which it is now received. This lowering in value of plantation rubber very much disturbed the planters, and those interested set to work to find out the reason.

The first consulted were the manufacturers, who, although their carefully conducted deliberations were of little avail on account of their want of practical knowledge of the conditions of cultivation both in the Far East and in the Amazon, were yet unanimous in declaring that the want of uniformity in plantation rubber gave rise, in the works, to miscalculations in the vulcanising process, a drawback which was never found with Para rubber. To find a solution of this problem, therefore, it became necessary to go back to the origin of the plantations and to the processes of cultivation and extraction, and above all, to that of coagulation.

Allowing that what cannot be remedied must be accepted, I will not discuss the botanical relationship of plantation *Hevea* to the Brazilian *Hevea*, which produces the true "Para" rubber. I shall also ignore methods of extraction and tapping, and begin my observations at the point where the latex is brought into the works to be transformed into rubber.

As soon as the plantations were ready for commercial exploitation the problem of coagulation presented itself, and the planters and chemists, who, with every reason, tried to find a more practical and quicker method than that employed in the Amazon, first of all took into consideration the mechanical methods employed in the factories for the conversion of raw rubber into rubber ready for manufacture.

They found that the raw rubber was first of all cut up and then passed through the washing mills to be made up into sheet or crepe, the preliminary stage and basis of rubber goods manufacture. To produce the rubber in the crepe form on the plantations appeared to them to be a step forward and a real economy, as it rendered unnecessary the lengthy and unpractical work of coagulation by the Amazonian smoking process. But to coagulate the latex in mass one had to stimulate, or rather hasten, coagulation by means of chemical agents such as acids in liquid form, which remain imprisoned in the coagulum ; whereas in the Amazonian method it is the smoke that hastens coagulation, and at the same time acts as an antiseptic. When the coagulated mass is obtained it has to be mechanically manipulated into a form which can be easily dried and conveniently transported to the consuming markets. Moreover, it must be in a form acceptable to the brokers, who are, by the way, more often than not, the real obstacle to an amicable understanding between the producer and the manufacturer, and who have in consequence hindered the progress which might have been made.

Difficulties presented themselves in the drying, the rubber becoming sticky and resinous and incapable of standing the action of ordinary daylight, still less that of direct sunlight ; besides which very powerful oxidation manifested itself as soon as the sheets were put up for packing. They then tried lightly smoking the sheets of rubber, but although this was found to be a slight improvement it did not give the degree of uniformity desired by the manufacturers. Then it was thought that in order to ensure the well-known qualities of the true Para rubber it would be necessary to adopt the methods of smoking employed by the Seringueros of the Amazon. Experiments were made, but they did not give the hoped-for results, and the failure was attributed by most people to the absence of the palm nuts or walnut shells used in the Amazon for the production of smoke. This reason, however, is not well founded. The South Americans, it is true, used these nuts by preference, but forest woods, both green and dry, are used in the smoking process just as often. I discovered certain of these woods in Malaya, but the results obtained by their use on the plantations were not the same as in Amazonia. By means of repeated experiments in the application of the Amazonian method in the plantation countries I established the fact that the failure arises from the difference in viscosity of the two kinds of latex, the plantation latex being much more fluid than the wild latex, even when gathered in the dry season and without the addition of water.

As I proceeded with my experiments I convinced myself that plantation latex could be smoke-coagulated, but that it would have to be by a totally different process from that employed in Brazil. I succeeded in obtaining a plantation rubber which was not sticky and which could be dried in the sun, and which would therefore stand the action of daylight perfectly. Also it dries more rapidly than crepe, and the oxidation during the voyage from the plantations to Europe is far less to say nothing more.

In my opinion there are many other factors which influence the quality of plantation latex. The age of the trees, premature and undue tapping, are matters which need to be studied seriously, but which are outside the limits of this discussion, and which, after all, could at present affect only slightly the value of the latex and the rubber obtained from it. The breaking up of the coagulum and its transformation into crepe sheets by the present type of machines are also prejudicial to the quality of the rubber.

An objection which has frequently been advanced against this theory is that since washing and creping mills were employed in factories it was hardly credible that they had an injurious effect upon the rubber. In saying this, however, it has been forgotten that when this operation is carried out in the factories the transformation of latex into rubber has already taken place, while on the plantations it follows immediately on the formation of the coagulum, the machines acting on molecules which are not yet completely united or formed, thus breaking down the nerve fibres which supply the elasticity and resilience of the rubber. The proof of this consists in the fact that the machines require a greater motive power in proportion to the time separating the period of coagulation from the washing and creping. If it is true that smoked sheets show a better quality than crepe this can only be due to the fact that the pressure exerted on the coagulum is very much less than the pressure necessary for the formation of crepe, and develops more slowly. The acid employed in coagulation being used in the same quantities for the sheets as for the crepe cannot be said to have any bearing on the difference of quality which exists.

In short, having failed to obtain an improved plantation rubber from the raw latex, we may next attempt to remove from the latter the elements which contribute to the lowering of its value, and this is why I am of opinion that it is absolutely necessary that the addition of water to the latex at the moment of collection should be entirely abolished; that the process of coagulation should be allowed to produce itself naturally and without the aid of acids and without any hindrance; and that the machines with tensile action which break up the elastic molecules before the end of the process of transformation of the coagulum into rubber should be suppressed.

I brought back from Malaya some rubber which had been coagulated naturally, and the latex of which had been gathered free from water. It was coagulated in the form of thin sheets and then smoked, and under analysis this rubber was found to be superior to many smoked sheet rubbers, and consequently superior to crepe of the highest quality.

But it must not be taken for granted that all methods of smoking are equally good for the rubber. Some make it dirty, and others cover the sheets with a resinous scum which is carried with it into the factory, and which is very difficult to remove in the breaking up process. Coconut fibre has the disadvantage that it causes too many sparks in the smoke and makes it necessary to filter the smoke as completely as possible. The shells of coconuts give an unduly resinous smoke which clings to the rubber, as is easily seen from the strongly discoloured water which flows from the sheets as soon as they begin to dry.

In Sumatra, and most probably in Java and Malaya, there is a wood called *bacouw* which yields an excellent smoke without dirt or resin. This wood is also found in South America, and the natives of the district of Beni in Bolivia know it by the name of *goyaboch*. It was with the fumes of this wood that I obtained my best samples of smoked rubber.

Continuing my researches in the production of an improved rubber which would give satisfaction to the manufacturers and which would simplify existing methods, I arrived at the conclusion that the last word has not been said on the subject of coagulation, either as regards Amazonian rubber or that of the plantations of the Far East.

Although the Amazonian process of coagulation by smoking gives good results it is certainly capable of improvement. During my various experiments I ascertained that it was absolutely necessary that the latex should be allowed to transform itself into rubber without any constraining factor whatever. By the old method of forming into balls, or by the more recent " drum " process it is evident that as the process of transformation only operates on a limited surface the contraction is consequently affected. The consequences are less important in the case of the drum system, as is easily proved when the sheet of rubber is separated from the apparatus. As phenomenon of transformation is not yet finished the contraction continues, and the sheet of rubber diminishes, proportionately with its rate of drying, in length, width and thickness; which cannot happen with the balls, where the interior layers limit the field of contraction of the upper layers.

In the system adopted on the plantations the phenomenon of transforming the latex into rubber is impeded from the very commencement of coagulation. I have already explained the reasons for this and will not repeat myself on this point. In all my researches I have been forced to the conclusion that it would be of advantage to discover a method which would be equally suitable for all *Hevea* latex, so that the manufacturers might be able to arrive at a universal method of vulcanisation, and thus solve the problem of uniformity in the raw product.

It has been said that with the Brazilian method of smoking the factor which above all makes for the good quality of the product is the creosote set free from the palm nuts generally employed, or from the shells of the Amazonian walnut (*Bertholbetia excelsia*), or perhaps by the action of the carbonic acid set free by these fumes. Starting from this assumption I coagulated *Hevea* latex by the action of smoke obtained from charcoal, or, to be more exact, by means of the carbonic acid disengaged by the charcoal. The rubber thereby produced was as good as the plantation smoked sheets, and had the further advantage of being free from the impurities present in the smoked sheets; besides which, there being no impediment offered to the process of contraction, it must be of better quality than the sheets which are passed through the calendars before being smoked.

But this method would not be very easy to carry out in practice, either on the plantations or on the Amazon. The production of carbonic acid from wood carbon would be too troublesome, and commercial carbonic acid is not easily handled and has to be very carefully manipulated. I thought it better to touch upon the matter, however, in this discussion, in order to prove that the improvements indicated could certainly be adapted to the present processes.

Many experiments were then made bearing upon the use of creosote. Sometimes it was simply added to the latex and the coagulation aided by raising the temperature; sometimes the latex was agitated with the creosote and the coagulum quickly gathered together and pressed into sheets. As a result I finally found a method which combines simplicity with other desirable features, such as the absence of acids and machinery. The coagulation proceeds naturally and uninterruptedly and the creosote insures that the coagulum will be aseptic. Naturally the amount of creosote employed is proportional to the percentage of coagulum from the latex collected, and I would here draw attention to the variations in homogeneity which are met with, according as the latex has been collected with or without water, this being in further support of my assertion that water is prejudicial to the quality of rubber.

The rubber produced possesses the following advantages :—

1. It contains no acid to render the rubber sticky and to prevent or hinder the process of vulcanisation in the factories.

2. The creosote is used in dilute solution only. Its density is greater than that of the water contained in the latex, and of the latex itself, and the drops introduced into the latex are found again after coagulation, the actual solution alone reaching the coagulum and rendering the rubber sufficiently aseptic to preserve it until it reaches the European factories.

3. No obstacle is opposed to the transformation of the latex into rubber, the process of contraction develops all its natural effect, the result being a very homogeneous rubber, full of nerve, stretching itself out more than 10 times its length for a thickness of 0.003 m. and at once returning to its original dimensions.

4. It resists the action of daylight and direct sunlight perfectly, and dries rapidly if it is preferred not to employ the mechanical method of vacuum drying, which is often the case on large plantations.

5. It represents a distinct advance towards the uniformity of quality required by the manufacturers.

6. It keeps perfectly. A sample made on the 1st February, 1914, and constantly exposed up till the 16th June, 1914, to all varying conditions of atmosphere, sea, and sun, still shows no traces of oxidation or fermentation.

Although in my experiments I dealt with only a small quantity of latex I am convinced that cold coagulation by means of creosote introduced direct into the latex, allowing the transformation of latex into coagulum to take place naturally, and followed by rapid drying, will eventually replace on the plantations of the Far East the methods which have been employed up to the present, and that it will mean great economy in the cost of upkeep of the plantations, even without taking into consideration the increased value that the rubber thus produced will have in the markets of the consumer.

The application of this method in Amazonia would give an even better result than that obtained by the "drum" system, and even more as regards the balls exported at the present time; obviating the arduous work of smoking and improving the health of the seringuero. It would take only 15 minutes of a workman's time to produce the coagulation, whilst the process of smoking takes at least one hour and a half, for an average production. The Amazonian labourer would, therefore have time at his disposal to devote to agriculture, and great economy would be effected in the running expenses of the exploitation of the Amazonian forests.

To sum up my researches from the point of view of the phenomenon of the transformation of the latex into coagulum and preserving the latter until it reaches the factory, I do not hesitate to repeat that one must not stray from the four following points :—

1. Coagulation should not be hastened by means of acids or heat, but should be allowed to develop naturally.
2. All mechanical action, which might rupture the elastic molecules before the transformation into rubber is completed, should be avoided.
3. The coagulum should be rendered aseptic, but only traces of the antiseptic should remain in the rubber.

4. Oxidation should be obviated by hastening the evaporation of moisture, either by drying in the sun or in the open air, or, on large plantations, by the mechanical processes of the ordinary drying machine or by the vacuum process, always provided that this operation does not expose the rubber to a too high temperature.

The CHAIRMAN: I have not been able to follow the paper as well as I might have done had it been given in English and not in French. The points I gathered, however, were sufficient to show that the process of coagulation proposed is certainly an interesting one. I think many of those who have been able to follow the French better than I, would be glad to discuss the matter.

Mr. STAFFORD WHITBY: I would like some information as to whether the author attributes the coagulation to the carbonic acid solely. All of us will recollect the Pahl process, which was explained to us at the last Congress in London.

Dr. SLOCUM: In that process was it not due to the hydrochloric acid. True carbonic acid did not coagulate.

Dr. STEVENS: I have been told that you can obtain coagulation with carbonic acid under pressure. I have no means of checking that statement.

The CHAIRMAN: The question was in my mind. In ever heard of the process being put to the test. I wondered myself at the time whether the mere mechanical part had not something to do with it, that is, the mere agitation to which the latex was subjected.

Mr. STAFFORD WHITBY: The carbonic acid dissolves in latex, but is not sufficiently acid to give complete coagulation.

Dr. SLOCUM: I should think such a method as that would produce very poor rubber.

The CHAIRMAN: I do not think the acid would remain very long.

Dr. STEVENS: All coagulum is more or less porous. The acid comes out subsequently.

The Coagulation of the Latex of Hevea Braziliensis, and its Bearing on the Strength of Rubber.

By

NEWTON W. BARRITT, B.A.

(International Institute of Agriculture, Rome).

In a previous paper* it has been shown that the coagulation of latex by means of acids and salts is analogous to the salting out of proteïns, and that the order of the coagulating powers of the bases follows Hofmeister's series. These results help to explain and co-ordinate the numerous phenomena that have been recorded independently by different workers, and discussions as to the maximum and minimum quantities of acid required to effect coagulation now assume a very different importance.

Since the coagulation curves for latex are of the type obtained in the coagulation of proteïns generally and not of the emulsion type, it may be concluded that the so-called nitrogenous constituent of latex and rubber is of a proteïn nature, and that its influence predominates in the process of coagulation. It now remains to be seen what effect the process of coagulation has on the physical qualities of the final vulcanised product.

Very little is known about the fate of the rubber constituents during vulcanisation, and it is not easy to imagine what properties of the coagulum or raw rubber would survive the severe physical and chemical treatment to which it is subjected during this process. Quite recently, however, Beadle and Stevens† have shown that the incorporation of substances such as peptone, and especially the so-called insoluble constituent of raw rubber, in a sample of rubber greatly improves its rate of cure and its tensile strength. These extremely interesting results agree with an observation made by Lock and Bamber‡ that a greater tensile strength is associated with a lower percentage of rubber and a higher proportion of organic matter and ash. The proteïn constituent evidently has a quantitative effect on the properties of the vulcanised product.

It has been suggested previously that the influence of the conditions of coagulation on the properties of the proteïn constituent might also appear in the vulcanised product, and experiments have been carried out to test this supposition.

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* Journal Soc. Chem. Ind. Vol. 23, No. 6.

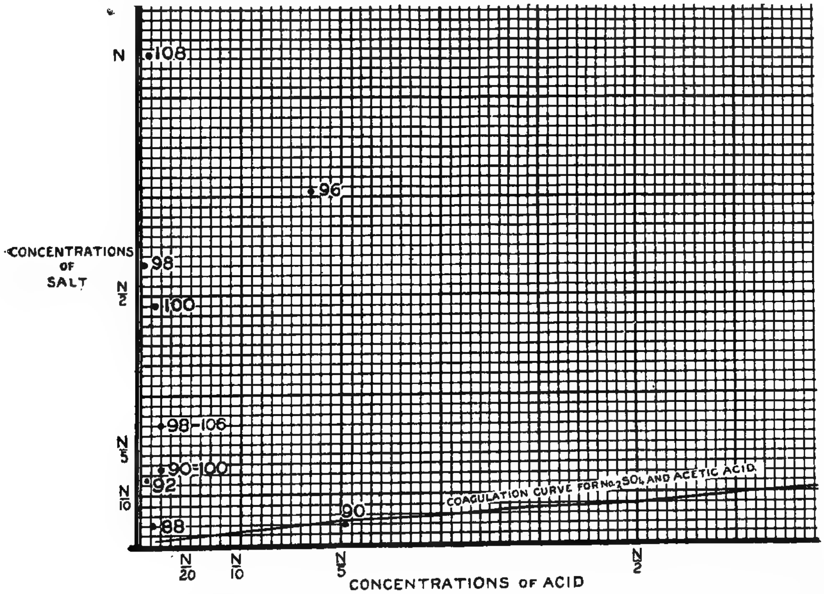
† India Rubber Journal, Feb. 28, 1914.

‡ Circulars of the R. B. G., Ceylon, Vol. V., No. 16. April, 1911.

A series of samples of rubber were prepared from the same bulk of fresh latex as follows :

	1	2	3	4	5	6	7	8	9
Vol. of latex used ..	cc. 500	cc. 500	cc. 500	cc. 500	cc. 500	cc. 500	cc. 500	cc. 500	cc. 500
Vol. of acetic acid added 1%	50	50	75	50	50	50	6 cc (10%)	50 (10%)	50 (10%)
Vol. of 5N sodium sulphate solution added	—	10	10	20	40	100	100	—	50
Vol. of water	—	50	—	—	—	—	500	—	—

The required quantities of salt solution and water were first added to the latex and thoroughly mixed. The measured volumes of acid were then added to effect coagulation. The various clots were allowed to stand in contact with their solutions for several hours. They were then washed and passed between smooth rollers each an equal number of times, and finally hung up to dry in an ordinary smoke shed. Samples 2 and 4 were cut in half, one half of each being smoked to a darker shade and used as controls. The sheets as prepared were submitted to the Silvertown Rubber Company to be vulcanised and subjected to manufacturing tests. I am indebted to the kindness and generosity of Mr. C. H. Gray for the results given in the following diagram.



(THE FIGURES REFER TO THE COMPARATIVE BREAKING STRAINS OF THE VARIOUS SAMPLES)

[Note.—The Editors regret that the original design for this diagram was either mislaid or lost during the Congress. The above was re-drawn from memory and is practically accurate.]

Assuming that the latex consists of 30 per cent. by volume of caoutchouc and 70 per cent. by volume of an aqueous solution of salts equivalent to a concentration of $\frac{N}{25}$ sodium sulphate, the conditions of concentration of salt and acid under which the respective samples were made, work out as follows :

	1	2	3	4	5	6	7	8	9
Concentration of acetic acid	$\frac{N}{50}$	$\frac{N}{58}$	$\frac{N}{35}$	$\frac{N}{54}$	$\frac{N}{56}$	$\frac{N}{240}$	$\frac{N}{120}$	$\frac{N}{5}$	$\frac{N}{6}$
Concentration of sodium sulphate	$\frac{N}{22}$	$\frac{N}{7}$	$\frac{N}{6.5}$	$\frac{2N}{7}$	$\frac{N}{2}$	$\frac{N}{}$	$\frac{N}{2}$	$\frac{N}{22}$	$\frac{6N}{10}$

These figures are plotted in the following diagram, showing their positions with respect to the curve of coagulation for sodium sulphate and acetic acid. The figures in large type represent the comparative breaking strains of the vulcanised samples, and the figures in small type represent their comparative rates of cure. It will be seen that, though all the samples were prepared from the same bulk of latex, considerable variation exists between them, and that the breaking strain of the samples prepared under conditions represented by the point just above the curve is considerably less than those of the samples represented by points further removed from the curve. The figures, however, show no uniform gradation, and since the difference between the two pairs of controls is so great and of opposite sign, it would appear that the experimental error of the results is too great for any accurate generalisation to be made. Nevertheless, the evidence so far obtained does not favour the present method of coagulation in the East, and though it is possible that improvements might be made by using solutions of certain salts in conjunction with acetic acid, there would still remain the inevitable variations in the composition of the latex. It has been proposed to meet these by means of a system of grading or standardisation, but, as has already been pointed out by numerous authorities, this is but acknowledging defeat, and once established would tend to check further progress. If the Amazon smoking method corrects the natural and accidental variations in the composition of the latex, is it not possible that some system of removing the excess water by evaporation under reduced pressure might meet plantation conditions ?

Dr. SCHIDROWITZ : We have listened to a very interesting paper which appears to me, if I may say so, to cover a very wide ground on a somewhat slender basis of experimental proof. That, however, does not make it any the less interesting. Mr. Barritt has succeeded in calling attention through his figures to the fact that variations in dry rubber may be due to both the quantity and the quality of proteins. That adds a new terror to variation. He suggests that the difference in results at Silvertown is due to error in the tests which were made at those works, but is it not probable that it was due to some error on his own part in his preparation of the samples ? If I have rightly understood his remarks in this connection they appear to me to be a very serious reflection on Silvertown, which possesses, as I know, a very effective scientific organisation. From my own experience I may say that such errors are quite out of the question now. I am not speaking by the book, or on the basis of any theory, but am speaking as a result of experience of many hundreds of tests. Only recently I made some comparative tests on the same sample of rubber, part mixed by a manufacturer and part by myself, and the results came out so close as to be substantially the same. That has not occurred once, but several times. Therefore, before accepting Mr. Barritt's conclusions, I would ask him to weigh them seriously. Where we are concerned with an error of something like 12 or 15 per cent.—it really means more than that, probably, if we look at the figures in a different light—I should ask him to consider the whole question very carefully before drawing anything like a definite conclusion. Coming to Mr. Barritt's observations on the subject of the breaking strain, unless we take breaking strain in conjunction with elongation at break, and the type of the curve and so on, the figures have only a comparatively small value. It is a pity, perhaps, that we have not these actual figures, but there are no doubt excellent factory reasons why we should not have them here. Mr. Barritt told us that the two samples made by him were made under identically the same conditions. I have had some considerable experience of samples apparently made under identical conditions, where later on it was found that for one reason or another the conditions differed in some small degree, but I think it may be taken that if you have the same latex and prepare the samples from it under identical conditions, and take proper care, they must give identical results. When I use the word identical, I am referring to vulcanisation results which must be a great deal closer than those suggested here. According to Mr. Barritt it comes to this, substantially, that vulcanisation tests made by one of the leading firms in the world, with a highly efficient organisation, give over 12 per cent. difference on the same sample. Mr. Barritt has referred to the effect of protein on vulcanising capacity. A number of papers have been published on this subject. I think the first was by Seidl, then we had one by Dr. Spence, and later Beadle and Stevens wrote upon it, while recently we had some more work by Spence. I myself recently made a series of experiments with a view to estimating the effect of protein on vulcanisation from a quantitative point of view, and while I found that there appears to be some general relationship, there does not appear to be any direct quantitative relationship. This appears to confirm the theory of Mr. Barritt that there is a qualitative as well as a quantitative difference in the rubber proteins. Finally the writer of the paper has expressed his opinions on standardisation, which by the way are quite at variance with the deliberately expressed opinion of the Standardisation Committee of the Rubber Growers' Association. He further suggests that we can get rid of all our troubles by adopting the Brazilian system. Well, I myself would like to have this thoroughly tested. That is a suggestion I first made in 1908. At the same time I would warn plantation people against adopting the Brazilian method on a large scale without first having fundamental evidence that the rubber it produces will average higher prices than the best plantation rubber at present commands. I know the best grades of plantation rubber do compare very favourably with the very finest wild grades, if we take into consideration the conditions of handling in the factory. That being so, I think that before adopting generally any new system, planters should make quite certain that they can produce an article to sell at better figures than plantation rubber is realising now. Growers should remember that one of the most important advantages in connection with the plantation rubber industry is that they can send rubber home clean and dry, and ready for use in the works.

Before abandoning that advantage I am sure they will consider the position very carefully.

Dr. ESCH: With regard to the observations in this paper on vulcanisation tests, in England the Admiralty test made by adding a large amount of zinc oxide is principally used. I have been recently making a number of vulcanisation tests on rubber prepared with an excess of sulphuric acid, made by Dr. Stevens or an assistant in a solution from the Federated Malay States. This stood well in the Admiralty tests, but I was not successful with the results of tests I made of this rubber over in Hamburg. I passed my sample on to a manufacturer who has been for many years largely engaged in making very fine cut thread rings. The rubber was vulcanised on a press mandril in the usual way. It was found that in the interior of these small thread rings small cuts or notches were always perceptible, as though the rubber had become cracked during the process of vulcanising. The rubber also had an extremely low tensile strength and an extremely low elongation as compared with those totally free from acids. I made tests but could not find any trace of sulphuric acid remaining in the rubber from the coagulation process, but in the vulcanisation tests the serious defect I have mentioned was to be seen very easily. On the other hand Messrs. Clayton, Beadle and Stevens could not see any serious defect. I draw attention to this point because, if you have a certain amount of mineral matter in your test mixings, the results may give another figure. I do not know on what kind of mixing the vulcanisation tests are made by the Silvertown works, but simply wish to draw your attention to this point. Afterwards the reader of this paper mentioned the results obtained by Messrs. Beadle and Stevens from the introduction of protein matter. I worked on the same lines, but did not use peptone, but the ordinary caseine as sold in small quantities. I use another method of introducing protein, in the form of a glue, taking 10 per cent. protein, 10 per cent. magnesia, and a small quantity of cold water to get a very stiff glue. You must not heat this glue, for it coagulates. You may introduce 15 per cent. of caseine into the rubber, using this caseine magnesia glue. If you afterwards get rid of the water, drying by means of smoke, so that the magnesia is turned into carbonate of magnesia, you get a very good rubber. You will find that if you exceed a 10 per cent. addition of protein you will not get a better result. I only worked on the preliminary lines, but found that if you exceed this 10 per cent. you cannot surpass the best results obtained in your Fine Hard Para. I only wish to draw attention to these points because my results are quite dissimilar from those of Messrs. Beadle and Stevens. They have found that the common caseine gives only very slow action, while the solid kind gave a better result. I, on the other hand, found that if you use the common caseine in the form of glue you get a very fair result. I got some samples made by manufacturers, and the breaking strain of these samples was better than the figures published by Messrs. Beadle and Stevens.

Dr. SLOCUM: May I ask Dr. Esch if the results he has mentioned of the vulcanisation of thread rings may not have been due to the formation of copper sulphite.

Dr. ESCH: Of course I made a test to see whether I could find any traces of copper in these small threads, but I could not discover any. The formation of sulphite of copper was prohibited, because the press mandril was covered by a solution of silicate of sodium, so that direct contact between the copper and the rubber did not take place.

Dr. K. J. THOMPSON: I should like to ask the reader of the paper if he will tell us whether all these cures were made at the same temperature and for the same time. Manufacturers know that they can get almost any strength they like by curing, and yet that in two months the stuff will come to pieces.

Mr. BURNARD: As a mere student who is casting about for the best practical means to be adopted on a plantation not yet in bearing I find myself in somewhat of a quandary. The writer of the paper rather leans in the direction, so I understood it, that it would be better to adopt a direct smoking coagulation. My difficulty comes in when the very eminent authority who followed him recommends that plantation managers should beware of how they change their present methods, which result in the production, as I understand, of a very pure form of rubber. I also understand that this purity is brought about by a process which depreciates the rubber of its nervic force. I should like to hear from Dr. Schidrowitz whether he recommends that the present method of maceration should be continued on plantations.

Dr. SCHIDROWITZ: It has been suggested that the plantation people should abandon their present methods and adopt a system similar to that pursued in Brazil. My reply to that is that plantation rubber nowadays possesses enormous advantages when it comes to the factories, in handling and so on. It is my opinion, based on a very large practical experience, and the opinion also of a very large number of manufacturers, that best plantation grades now are as good as, and in some cases better than fine Brazilian grades. You must be quite sure before altering your methods that you are going to reduce variability and produce an article that will be as good as the best wild rubber, while triumphing over its disadvantages, such as the necessity for cleaning, etc.

Dr. ESCH: Would you abandon the washing of plantation rubber altogether?

Dr. SCHIDROWITZ: I only say that it should not be washed unless absolutely necessary.

Dr. ESCH: I may state that in my experience, and I am consulting chemist for a number of European and American manufacturers, I have generally found that if you are going to use the plantation rubber for higher classes of goods, such as thread rings, or inner tubes, the plantation rubber has to be washed, chiefly for the purpose of getting away the last traces of acetic acid. Nowadays they mostly wash the rubber.

Dr. SCHIDROWITZ: Dr. Esch says that nowadays they mostly wash plantation rubber in the factories. That is a question of opinion. I know manufacturers in this country and America who make up the best goods, and use up far more rubber than is required for elastic thread or inner tubes, etc., and they do not wash their rubber. They select that which is already clean. Dr. Esch, I think, will agree with me that the more often a rubber goes through the machines, the more likely it is to lose strength. If he says that he knows a number of manufacturers who continue to wash their plantation rubber, I may say that I know many others who do not.

Dr. ESCH: If I were a manufacturer and made in especial tyres that contained a large amount of oxide of magnesium and such like I would not wash the rubber. It often occurs that you have not compounding materials of a neutralising nature in your mixings, and in such cases it is necessary to wash the rubber. If you get a mixing of alkaline material like zinc oxide you do not need to wash the rubber, but if it contained sulphur only I would wash it.

The CHAIRMAN: This discussion is getting distinctly away from the point. There are other papers in connection with which these matters may be discussed. Let us get back on our track.

Mr. W. T. GIBSON: Mr. Barritt makes out a coalition between the amount of sodium salt added and the tensile strength of the rubber. He claims that the effect is indirect; the salt acts upon the protein, and the protein has its effect in vulcanisation. But it appears to me that there are two more direct effects of the salt. One of these is a possible catalytic action upon the vulcanisation process, resulting in an increasing tensile strength. The second point is this—I do not remember what particular amounts of the sodium salts were added, but it is possible that so much was added that it affected the direct tensile strength.

Mr. P. J. BURGESS: I would like to put it seriously to Mr. Barritt whether, in view of the fact that a 12 per cent. variation was shown in the results of the tests made, he considers that the experimental results show any tendency whatever?

Mr. BARRITT: In replying to the various points that have been raised, I may say that the reason I selected the Silvertown works was because they have an established reputation in the rubber industry. I am not prepared to discuss the quality of their work. For myself, I do not know anything whatever about the chemistry (?) of vulcanisation, and have not seen the process. In my work of making the samples every precaution was taken that exactly the same quantities of salt and exactly the same quantities of acid were used. There is no very difficult method required to add salts or acid to latex. I can say nothing more on that question. With regard to the variations in the vulcanisation tests, Dr. Schidrowitz says that he obtains very regular results. I have yet to find the paper which says that any effort has been made to determine the experimental error of the vulcanisation tests of a given sample of rubber. Dr. Schidrowitz also issues a warning against any change of plantation methods in favour of something that has not yet been tried. I think something should be attempted to carry out the Brazilian method. It has been tried longer than the plantation method. One gentleman asked me if I included the conditions of the rate of cure in these particular vulcanisation tests. In submitting the samples to Mr. Gray, of the Silvertown Company, I asked him to give me results strictly comparable one with another. You will find the figures more definitely stated in the paper that is being printed. Another gentleman made a very useful suggestion which would knock a great hole in my paper, about the catalytic results of salts on vulcanisation. In thanking him for the suggestion, I must confess that I overlooked that point. In a previous paper I have given figures showing that the concentration of the salts in the coagulum is very slightly affected by changes in the concentration of the serum of the latex. The increase of salt would be very slight indeed, and the amount of salt in all samples of rubber varies quite as much as it would do in these experiments. The results outlined in my paper require further confirmation. I do not claim anything absolute. I put them forward to suggest further work in confirmation of them. It seems to me extremely probable that the salts have some effect upon the physical properties of the protein and of the resulting rubber.

The Chemical Coagulation of Rubber Latex.

By

FREDERICK KAYE, A.R.C.Sc.

Rubber Latex is a physiological fluid coming from laticiferous tubes which are part of, or lie close to, the vitally active protoplasmic cells of the cambium layer. This fluid is generally neutral or slightly alkaline in reaction and consists of globules of virgin rubber material floating in a serum of a somewhat complex nature.

The Plantation method of chemical separation, or coagulation, of the rubber from the latex is to add acid—chiefly acetic acid—until a point of acidity is reached that gives the rubber coagulum without any milkiness remaining in the serum. This simple chemical operation has never yet been really fully interpreted. Hence the incessant discussion as to the variability of Plantation Para Rubber. The quantity, and nature, of the acid used affects the physical texture, colour, etc., of the resultant commercial product; but below the visible effects lie subtle materials which by their nature and quantity ultimately largely determine the quality and stability of the final manufactured vulcanised article. While remembering the electrical condition of a rubber latex and the physical explanation of the process of coagulation, it is well for us, from a practical point of view, to keep our attention to the chemical side of the problem.

The more close study of the protein compounds in the serum demands urgent investigation, because, it is my belief, these fugitive chemical entities by their vagaries are the primary causes of rubber variability. I have previously called attention to the fact that the study of the comparative coagulative value of different coagulants should be conducted with equivalent quantities. I, myself, always work with normal or tenth normal standard solutions and in this way the interconnection with molecular functions is determined. Hardy has shown that as regards the salt formation of serum-globulin by means of acids and bases the combining power of these bodies as determined by a standard degree of opalescence, as expressing the solvent action, was in the case of the strong acids a molecular function, and that

$$\mathrm{H\,Cl} = \mathrm{H_2\,S\,O_4} = \mathrm{H_3\,P\,O_4}.$$

He also showed that weaker acids, as acetic acid, required relatively far greater quantities to produce the same grade of solution: this is due to the readiness with which the salts undergo hydrolysis in dilute solutions. Hardy worked with very dilute solutions. The concentration of the acid was ·005 N and the suspension of globulin content with 0·28 to 4·18 gns. in 100cc. Similar experiments were carried out with bases. Taking Na OH as unity the relative solvent action may be represented by the following figures (given in equivalents)

$\mathrm{Na\,OH}$ = 1
$\mathrm{K\,OH}$ = 1
$\mathrm{N\,H_4\,OH}$ = 0·98
$\mathrm{Ba\,(OH)_2}$ = 2·008

Taking Parkin's original figures as to the quantity of acid required to effectively coagulate plantation Para latex at the point which gives complete separation without re-solution of the protein, etc., to give milkiness, and expressing these quantities in terms of deci-normal solutions an apparent similar relation appears to hold. Parkin worked with latex which was considerably diluted and this may explain why he used larger quantities of some of the acids than are now used in factory practice on the plantations.

Coagulant		Basicity		CC $\frac{N}{10}$ Solution required to coagulate 100 cc Hevea Latex
Sulphuric Acid	..	di-basic	..	20 cc
Hydrochloric Acid	..	mono-basic	..	9 cc
Nitric ,,	..	,,	..	31 cc
Acetic ,,	..	,,	..	150 cc
Oxalic ,,	..	di-basic	..	31 cc
Tartaric ,,	..	,,	..	33 cc
Citric ,,	..	tri-basic	..	71 cc

Recently B. J. Eaton published a paper on the "Preparation of Plantation Para Rubber" in which he gives the minimum quantity of coagulants necessary to give complete separation of all the rubber from a normal latex, containing 30% of rubber, without dilution. I have taken some of the acids in his list and calculated the amounts he gives in terms of number of cc. of $\frac{N}{10}$ Standard Solution of acid required of 100cc. of latex. My figures are given in column No. 3.

1. Coagulant		2. Grams per 100 cc. of latex		3. No. cc $\frac{+N}{10}$ solution. (approximately)
Acetic Acid	..	0·10	..	16·6
HCl	..	0·07	..	20·0
$H_2 S O_4$	..	0·09	..	20·0
$H. N O_3$	..	0·10	..	20·0
Citric Acid	..	0·17	..	27·0
Tartaric Acid	..	0·17	..	22·0
Formic Acid	..	0·06	..	20·0
Oxalic Acid	..	0·10	..	20·0

Here we see that working with undiluted latex the effect of the coagulant is proportional to the available hydrogen and is connected with the hydrolysing power of the coagulant.

The one great problem left for solution by the Plantation Industry is to discover the real inwardness of variability, and if possible to overcome it. My study abroad of different latices, and some recent experiments of mine in London, have suggested to my mind what is perhaps the cause of variability. The mineral constituents of latex and of technically pure rubber have hitherto been largely disregarded, and this is true especially of one constituent of latex—the phosphorus component. I have come to the conclusion that the study of this can open up a new and clearer vision of the problem and its method of solution. Fine hard Para, as you are aware, is the native product produced by concentration and almost instant solidification of the materials of the latex whereby the protein and mineral components are entirely thrown out with the rubber under conditions utterly dissimilar to that which must hold in the case of wet coagulation. In the latter case there is a large separation of the coagulable material from the non-coagulable, the proportionality and quality of which are peculiarly sensitive to the apparently slight variabilities as to state of dilution, the temperature, and concentration of the coagulative agent. I have analysed as to their Phosphorus content a few samples of technical pure Fine Hard Para kindly sent to me by manufacturers in different parts of the country. The following are the figures :—

		Calculated on the Rubber.	
Sample	Ash	P_2O_5	Phosphorus
Fine Hard Para (1)	·332%	·0520%	·023%
Fine Hard Para (2)	·375%	·0805%	·035%
Fine Hard Para (3) Outside of Ball	·286%	·0624%	·027%
Fine Hard Para (4) Inside of Ball.	·216%	·0620%	·027%

Showing that the Phosphorus content is approximately constant.

Clayton Beadle and Stevens have given the total quantity of phosphoric acid found by them in three plantation latices :—

	A	B	C
	Latex from trees tapped on alternate days.	These were from trees more severely tapped than A.	
P_2O_5	0·13%	0·09%	·06%

I have just been working with a good quality latex preserved with Ammonia sent to me from Malaya. Below are some of my results.

Total Solids (nearly dry)	36·91 grms. from 100 cc. latex.
P_2O_5 in 100 cc. latex from ash determination	0·046%
Phosphorus	0·019%

This, calculated on the nearly dry coagulum is :—

P_2O_5	0·124%
or as Phosphorus	0·054%

100 cc. of latex was coagulated with Acetic acid and the amount of phosphorus determined after incineration.

	×— P_2O_5	× Referred to latex Phosphorus
Acetic acid coagulum from 100 cc. of latex	·010	·0043

Similarly the phosphorus in the following was determined :

	Ash	P_2O_5	Phosphorus
Pale Plantation Crepe	0·17%	·035%	·015%
Best Smoked Sheet (unwashed)	0·312%	·092%	·040%
Byrne Cure (unwashed)	0·555%	·162%	·070%

It appears to me that a thorough study of the quality and nature of the phosphorus in the latex will give a means of more clearly understanding the natural, or chemical character, of the changes taking place in the protein components under the effects of enzymic action, dilution with water, and the hydrolysing results brought about by acids or alkalies. The phosphorus-containing proteins of plants and animals are bodies of large complexes. These substances having high molecular weights and being compounds of compounds of considerable complexity they readily break down through stages to bodies of relatively high molecular magnitude.

The proteins containing phosphorus are called nucleo-proteins, and in the earlier stages of degradation a scission takes place of definite groups, which are often of large molecular weight. These groups are called *prosthetic groups* and the one which has undergone considerable study is nucleic acid. This body, nucleic acid, which is still very complex, easily suffers further breaking down, and the degree of degradation varies with the agent employed in hydrolysis. By very gentle hydrolysis with acids or alkalies intermediary decomposition products of nucleic acid have been obtained. Such products are richer in phosphorus than the acid from which they are prepared. Nucleic acid appears to undergo some decomposition on treatment with water at 60°. The following groups of degradation products have been obtained from nucleic acid :—

(i.) Formic acid.
(ii.) Ammonia.
(iii.) Phosphoric acid.
(iv.) Carbohydrates, or carbohydrate derivatives.
(v.) Various bases.

Phosphoric acid is obtained in considerable quantities by the hydrolysis of nucleic acid. It forms an important part of the molecule. The relation of this phosphorus to the bases, etc., of the molecule is a matter of chemical speculation and research that in this paper we cannot enter into.

I think we can realize that the complex protein contents of rubber latices are very sensitive to enzymic action or to that of hydrolysing agents. It is therefore exceedingly difficult, unless the utmost care is exercised, to standardize the method of chemical coagulation. For, if the period lapsing before coagulation is brought about is very variable, the difference in the duration of the natural enzymic action must affect the product. The state of dilution and temperature of latex will also have caused the degradation to reach a certain stage and character before the acid hydrolysing action commences. Different conditions of chemical coagulation will give different qualities and composition to the nitrogenous components of the rubber and also to the mineral substances—phosphorus, etc.,—associated with them.

That the effect of acid upon the latex when it brings about coagulation is any hydrolysing one is shown by the fact that the time required for its action is often many hours, but that acceleration is brought about by increased concentration of acid and an increase in the temperature at which the experiment is conducted. In many experiments with different latices—Castilloa, Plumaria, Hevea, etc., I have discovered that if the acid remaining in the serum after complete coagulation is determined it is greater than the original acid used. In the case of Hevea it is approximately twice the amount of acid taken. The actual nature of this remaining acid I have not yet fully determined but I am of opinion that it is phosphoric acid produced by the hydrolysis of some of the protein groups. If this is so, I think it will be found that the elimination of this phosphoric acid from the coagulum has an important bearing upon the strength and quality of the crude rubber.

Schidrowitz has shown that the quantity of acid used to effect coagulation had an effect upon the vulcanising capacity and strength of the rubber. He had prepared samples of rubber sheet from the same latex using varying quantities of acetic acid, from a unit quantity of acetic acid to amounts reaching 24 times as much. He found that the least quantity of acetic acid gave the best product. The determination of the phosphorus contents of these samples would I think throw much light on the problem. The phosphorus content of the protein of rubber may have an influence upon the quality of the rubber similar to that which the phosphorus of the gluten has upon the quality of flour in its use for bread baking.

Phosphorus in flour is not present in the form of phosphate. This is true of its state in the ash only. A large proportion of the phosphorus in flour is present in organic combination. Flours from weak wheats, which are generally poor in gluten, contain less proteins than flour from strong wheats which are rich in gluten. But by the use of improvers flour from weak wheats simulates flour from stronger wheats although as regards protein content it is inferior to the flour which it imitates. It has been found that the addition of certain mineral salts, chiefly phosphates, exercises remarkably improving effects upon the bread baking quality of the flour. The increased elasticity of the gluten is one of the changes helping in this. The amount of mineral phosphates necessary to effect this is only very small. For example 1 oz. to a sack or 1 part in 4,480 or 0·022% or calculated in proportion to the bread it is an addition of ·014% of mineral matter to that natural to the wheat. The loaves produced show an improvement in value equal to 1s. to 1s. 6d. on commercial value of the flour.

I am conducting a series of analyses of many samples of plantation Para and Fine Hard Para rubbers with regard to their phosphorus content, and these figures, in connection with the determination of the protein content of the coagulum, will I feel sure shed illumination on the fascinating and commercial problem of variability.

The CHAIRMAN: Mr. Kaye has given us a very interesting paper, containing some new points which are well worth some discussion at this juncture, and a good deal of thinking over. The amount of discussion just now depends on how much the remarks are condensed, as there is still a lot of work for the Congress to get through.

Dr. SLOCUM: I would like to ask Mr. Kaye if he has examined the phosphorus content of the serum of naturally coagulated latex to see if that is any smaller than when acetic acid is used.

Mr. A. BRUCE: Are these figures calculated on the dry rubber ash?

Mr. KAYE: I might refer to that. All these samples have been factory washed samples. They were sent to me after being carefully washed by manufacturers. Numbers 1, 3 and 4 were specially finely washed and very thin. They were washed much more than Number 2. The amount of phosphoric acid is really calculated on the dry rubber. The estimate of ash in plantation rubber specimens comes out somewhat similarly. The physiological point I would like to bring up is that latex is generally supposed to be a waste product. It seems, however, to be impossible that Nature should throw away such an important constituent of its living tissues as phosphorus. The production of latex in the trees is increased immediately the seed crop has issued. It seems that there is some relation between the latex and the seed production. The phosphorus having produced the seed, after the seed has been issued the latex is more prolific.

Dr. STEVENS: Mr. Kaye has made a lot of analyses, and uses a lot of figures which would require very careful study before one would be inclined to criticise his theory with regard to the effect of phosphorus on the quality of the rubber. Of course latex contains not only phosphoric acid but also the two other important ingredients, potash and nitrogen, and I for one do not think latex is a waste product. With regard to the percentage of acid affecting the quality, there is no doubt about that. The only thing to do to obviate this variation is to standardise in the preparation. There is one fact in connection with Mr. Kaye's theories that I can deal with, and that is that it is quite possible to produce satisfactory vulcanised rubber without phosphoric acid. Experiments that I have made remove all insoluble matter. I use peptone, which is free from phosphorus, so that I am able to replace the actual protein by this protein and so to vulcanise the rubber. I would not like to say that phosphorus has not something to do with the keeping quality, but it is quite possible to vulcanise rubber which contains no phosphorus.

Mr. W. T. GIBSON: One point brought out by Mr. Kaye's paper is that coagulation under modern conditions is due to the coagulation of protein. For some time there was doubt as to what were the factors in coagulation. We had a purely physical hypothesis which thought that a chemical action of coagulation took place in the coagulation of the protein, but of course still in certain cases it is possible that there is coagulation by purely physical methods. For instance, when latices are diluted and they coagulate by dilution it is entirely physical. If the latex coagulates on dilution we can put that down to the weakening of the emulcifying effect of the protein which results from the dilution. Whether nucleo-protein is found in the latex when drawn from the tree would depend on how far the cells of the cortex have been destroyed so that the nuclei have passed into the latex. I do not know any reason for believing that nucleo-protein exists as such in the latex itself. There is a question as to whether the phosphorus can really refer to the nucleo-protein. Various kinds of phosphorus exist in the latex, and presumably phosphates. Mr. Kaye mentions that the acidity of the latex can be found in greater quantity than is accounted for by the acid. Is there any possibility of bacteriological action increasing the acidity? I do not think so, but of course the reaction of the latex after the addition of the acid would prohibit the action of acid formed by bacteria. What actual reasons has Mr. Kaye for referring the variations in the rubber to the phosphorus? There are a lot of varying factors in rubber. A lot of the constituents vary, and what reason has he for picking out the phosphorus specially? That variability may be largely due to the percentage of salts can be guessed at when we look at the analyses of plantation rubber, especially crêpe.

Mr. KAYE: This paper of mine is but the beginning of what I hope to be a considerable amount of work. What I have tried to do was to put a vision before you that might be the means of illustrating and explaining variability. I want you to see that the nature of the phosphoric acid, the quantity and nature in different rubbers, may give us a clue to the stages of the process of change that is taking place in the protein content of the latex in the varying circumstances of coagulation. I do not know if I made that quite clear. I merely spoke about the nucleo-protein as a protein which we know contains phosphorus, and I pointed out its qualities and sensitiveness to rapid change. I cannot in a brief time explain all that is in my mind, and behind what I have given there is a deal of the insight which is required to fully understand what I think these ideas of mine might go some way to explain. Yesterday Dr. Lock was speaking of the formation of rubber in the laticiferous cells, and there was one interesting point which seemed of great importance to me. I think he said, if I am right, that the nuclei of the cells are always on the side of the cells adjacent to the laticiferous vessel. The nuclei of the cells are those parts of the protoplasm which contain phosphorus. What I wanted to say is that a complete study of the phosphorus in all the changes that take place in the latex will illustrate very largely the process of coagulation. The value of the phosphorus in the vulcanising of the rubber is really an indication as to two things. There is the quantity of the phosphorus, undoubtedly a factor, but it also will reveal by further study the quality and the nature of the proteins. If you understand something about these proteins which contain phosphorus, of which I tried to explain, you will know they are extremely large complexes that break down through certain stages, at some stages containing phosphoric acid, until you come down to basic substances and carbo-hydrates. In a paper I wrote for the *India Rubber Journal* last year I gave some figures with regard to the determination of the acid remaining after coagulation. I repeated these experiments and found that to effect coagulation there is always twice as much acid remaining in the serum as is put in. If you take 60 cubic centimetres $\frac{N}{10}$ of acetic acid, the acid found in the solution is 120 cubic centimetres $\frac{N}{10.}$ Using 150 cubic centimetres of acetic acid $\frac{N}{10}$ the acid remaining is approximately 350 cubic centimetres $\frac{N}{10.}$ In this way you have revealed in a most convincing manner the nature of the change taking place under the influence of acids. When you take the latex from the tree it is a complex fluid which is part of a living organism. Immediately it is detached from that organism, changes take place, enzymic action occurs, acid is produced, and coagulation takes place naturally. But if we add water it brings about a certain specific change. What I want to say is that here is a view I have pointed out which may lead to the solution of a great many difficulties. These figures that I have brought before you are only the beginning of the figures we may have. I think that if we carefully find out how much phosphoric acid there is, and at the same time we find out how much nitrogen there is in a rubber, and if the co-relation between them is found out according to the temperature of production and so on, the relation between these two factors will vary. It has been suggested to my mind that the determination of the amount of phosphoric acid will lead to a method for the determination of the protein.

The Protëids in Caoutchouc and in Latex.

By

Dr. FRITZ FRANK,
Berlin.

During the last few years a large number of investigators have emphasized the importance of the protëids contained in caoutchouc latex and in the separated rubber; it is, therefore, not necessary to review, at this time, all the details of these investigations. It is sufficient to point out that it was well known before Spence's investigations that there existed a body containing nitrogen, which was, in some way, of importance to the rubber substance. At first it was surmised that the existence of this body in rubber might have only a mechanical significance, but later it has been proved, particularly by Soidle's investigations, which have unfortunately been frequently overlooked, that the presence of this substance is significant because the vulcanization of the rubber is influenced by it to a considerable degree. For a long time it was not possible to recognize with certainty whether nitrogenous substances were present. Beadle and Stevens, Kirchhof, Schidrowitz and others have further proved the importance of this substance in technical manufacture. I, personally, have only published briefly on the subject, waiting until I had completed a satisfactory amount of experimental work.

In collaboration with Drs. Marckwald, Mosinger and Wurm I first of all investigated the question whether it was possible to isolate quantitatively the nitrogenous body, thus making its determination possible. As I have stated in a preliminary notice published in the "Gummi-zeitung" in conjunction with Dr. Marckwald, it is, to a certain extent, possible to answer this question in the affirmative, and this statement has been confirmed by many further experiments. These experiments uniformly show, however, that only a certain constant proportion of the nitrogen bearing substance can be separated, the rest being lost; but the analytical process employed can nevertheless be characterized as useful, to a certain degree, and it has been further shewn that it is of some assistance in the technical valuation of the caoutchouc. The more nitrogen is found quantitatively in the quantitatively separated substance, the better will the rubber work technically, and the better will be the results obtained by either hot or cold vulcanization. The less nitrogen found in the separated substance, the more have the valuable protëids originally present been destroyed or separated during the process of manufacture. The analytical process employed by us and recommended for use is as follows:—

From 1 to 2 grams of raw rubber are placed in a strong test tube 30 mm. in diameter and heated with 30 cc. of cymol, limonene, or dipentene in an oilbath at the boiling temperature of the solvent, with reversed condenser, till a uniformly thin solution results. The rubber is now so broken down or depolymerized, as to be only slightly precipitable, while the protëids and other insoluble foreign bodies remain suspended in the solution. The test tube is now placed in a centrifugal machine (made by Collatz & Co.), which is then run at a speed of 2,500 to 3,000 revolutions per minute, for 1 to 1½ hours. The solution will now be clear and the insoluble matter will be found at the bottom of the test tube as a sediment. The solution may now be poured off, the residue being again shaken up with xylol, boiled and again centrifuged. It is then treated in the same manner with benzol, and lastly with ether, in order to remove all soluble rubber substance. The resulting sediment, having been dried, is weighed and may then either be reduced to ash, used for a nitrogen determination, or tested for the presence of other substances such as tannin, etc. The results, which for purposes of comparison were obtained in this manner by different experimenters, do not, as a rule, differ from each other by more than 0·1 per cent.

The determination of nitrogen and the characterization of the other foreign bodies, if any, can be accomplished with certainty. All these experiments, which were carried out with several hundred samples, were studied in connection with the manufacturing results obtained by the use of the various raw rubbers examined, and the results always showed a very fair degree of conformity between the content of nitrogen-bearing residue and the technical behaviour of the rubbers. Since, therefore, a process has now been found which is free from objections, and capable of giving good results when carried out by different experimenters, it seemed to me that this part of my work could be considered as finished, and I can therefore hand over the process as above described to my professional colleagues, for their own use.

It should be mentioned in connection with this process, that it has been proved beyond doubt that no decomposition of the nitrogenous substances takes place during the boiling with the solvent—at any rate none that results in volatile substances. In no instance have either ammonia or amines been detected in the vapours, though often searched for. Moreover, for safety's sake, indifferent gases had been led through the boiling liquid for the purpose of carrying away with them any possible decomposition products. In these cases as well, neither ammonia nor amines could be detected even with the most sensitive reagents.

After the conclusion of the above-mentioned experiments, and also concurrently with them, other experiments have been made, in order to obtain further information regarding the nitrogenous substance. In the meantime, however, Kirchhof and others had stated that they could actually characterize this substance as albumen by the known reactions. The tests we applied to see whether we were really dealing with protëids on all the separated, insoluble materials; in certain cases the products were taken up with alkalies, and then again separated. The biuret reaction was, in all cases, obtained with undoubted clearness, the xanthoprotëic reaction and the sulphide of lead reaction gave positive results. Millon's reagent, which allows conclusions as to the presence of tyrosin groups, was very strongly marked, and later on tyrosin could be proved with certainty in most of the products. Usually this typical decomposition of albumen was complete, though sometimes a partial decomposition was externally recognisable.

Liebermann's reaction proved unreliable, but all precipitation reactions characteristic of the known albumens were observed with certainty. In order to study these albumenous substances more closely, larger quantities of it were isolated by the above described working process. It is true the quantities so far obtained were still comparatively small, yet we succeeded in carrying through a number of hydrolytic reactions. It was proved with certainty that the products obtained from the insoluble portion of the caoutchouc by complete hydrolysis agreed completely, so far as could be observed, with those found separated in caoutchouc latex and in the serum after coagulation. The products obtained were hydrolysed by means of sulphuric acid, and it was further attempted to liberate the characteristic groups. As the relatively small quantities obtained were difficult to separate, and the individual isolation was prevented, chiefly by the sugar and allied substances, we had first of all to occupy ourselves with the characterisation of groups resulting from the breaking down reaction. We identified beyond doubt monoaminomonocarboxylic acids, amino acids of the aromatic series (phenylalanin and tyrosin), amino acids of the heterocyclic group (tryptophane for certain), diaminomonocarboxylic acids and, also, with fair certainty, monoaminodicarboxylic acids and cystin. The further treatment and further characterization of the individual substances remains to be worked out, and I hope to be able at a not very distant time to make more explicit statements regarding the individual substances which are obtained by the breaking down of the albumens obtained from caoutchouc serum, etc., in order to be able to come to a decisive opinion regarding the composition of these albumens.

Before I draw technical conclusions as to the results obtained, I would like to point out that it has almost always been possible to prove the presence of amino acids even by means of Abderhalden's reagent, ninhydrin, and this is particularly the case, as already stated, with those products which show externally slight signs of disintegration.

Some technical conclusions may now be drawn from what has been said above as to the importance of the albumens in caoutchouc. It is evidently necessary to so manage the coagulation of the latex that the albumens remaining with the rubber at the time of and after its separation from the latex are obtained in such a manner that a further disintegration does not, and cannot, take place, or, at least, to a very slight extent. Meanwhile a process has incidentally been patented for the separation of caoutchouc from the latex which, perhaps largely on empirical grounds, makes use of the theoretical conclusions drawn from the work described above. It is the much discussed Colloseus process (German patent No. 259253, English patent No. 22255/12, etc.), by means of which it is indeed possible to obtain a large portion of the albumens from the latex in the theoretically desirable, insoluble, and rather indifferent form of salts of the alkaline earths, etc. This is accomplished by causing, first of all, the formation of water soluble alkali salts, which are transformed by double decomposition into difficultly soluble compounds which separate with the caoutchouc.

Experiments here indicate that the process is really good, and it appears important to follow it up with large practical tests. It has been interesting to see how in this case theoretical considerations, based on scientific work, and the activity of the practical inventor are in accord, though working from different standpoints. For that reason it appeared to me also important to make the foregoing statement in order to encourage and guide in this way the continuance of practical experimenting.

The CHAIRMAN: There will be some difficulties about discussing this paper, on account of the fact that it is only intended more or less as a summary, or merely a preliminary notice, because there are so many statements made with comparatively slight evidence in detail. I am certain there are a good many points on which we should all of us like more detail. However, there is considerable to discuss.

Dr. SLOCUM: Dr. Frank is not here to answer, but he speaks there about testing for the amino-acids and so forth in the vapours. They are not at all volatile, and they are not likely to be present in the vapour, but they would dissolve in the limonene used. There is a considerable amount of nitrogen in the acetone extract, and it has been proved that some of the ash is also in the acetone extract. The question is whether all your nitrogen is thrown down in an insoluble form. Dr. Frank does not seem to have done any work on those lines.

The CHAIRMAN: I do not see that he has. There is nothing about the amino acids, but there is evidence offered as to the absence of amines and ammonia. There is one fact about acetone extractions that is sometimes overlooked. Under no circumstances is extraction as ordinarily conducted completely anhydrous unless special precautions are taken which are ordinarily unobserved.

Mr. STAFFORD WHITBY: I am not quite sure whether Dr. Frank means to convey the idea that the greater the total quantity of nitrogen not soluble the better the vulcanisation, or the less——

The CHAIRMAN: He says "the more nitrogen is found quantitatively in the quantitatively separated substance, the better will the rubber work technically and the better will be the results obtained by either hot or cold vulcanisation. The less nitrogen found in the separated substance, the more have the valuable protëids originally present been destroyed or separated during the process of manufacture." I should think he means that the more nitrogen is found the better the rubber will work. I should hardly have thought there would be any such linear relationship as that.

Mr. W. T. GIBSON: Dr. Esch's patent for working the protëin in the pure rubber bears on this question. He mentioned it the other day.

Dr. SLOCUM: Perhaps some of the gentlemen here who are closely in touch with plantation work will let us know something of their observations as to whether the protëin content is increased by the variation of the coagulation method; as to whether increasing strength is found, or the protëin present is alkaline protëin.

The CHAIRMAN: That is more likely to come out in the factory than on the plantation. Probably most of us have seen the curious spectacle, in handling on a large scale, of a solution containing something like a ton of rubber which for some reason or another has settled for a long time and has been standing for months without being disturbed, and which drawn off from the top is as limpid as water. On precipitating such a solution I observed myself years ago that the product obtained was in the first place almost as white as a light plantation crepe, and even in the unvulcanised state was almost dead, possessing hardly any elasticity and being so soft that it could hardly be kept anywhere. I vulcanized with great difficulty. Of course, exactly the reverse was true of the remainder; it showed precisely the opposite features.

Mr. STAFFORD WHITBY: I might just point out that this is an extremely difficult question to investigate with any degree of finality, and it is most difficult to interpret results. Assuming that there appears to be some relation between the amount of insoluble nitrogen and the vulcanising quality of the rubber, we cannot at once rush to the conclusion that that is due to the differences in the nitrogen content. Of course it may simply be symptomatic of some difference in the caoutchouc. It may be that that particular sample of rubber was prepared in such a way that the caoutchouc was in a high state of aggregation, which would give good vulcanising results. With regard to the point raised by Dr. Slocum as to the results of experimental work in plantation rubber, there again if you prepare different rubbers by different methods it may simply be that the different results are due to the different ways in which you have performed the preparation. I cannot pretend to have done any extensive investigation on this point, but we have examined various samples of rubber analytically and from the point of view of vulcanisation, and comparing different forms of rubber it does not seem to me that there is any relation between the protëin and the vulcanising quality. I should be very interested to know whether Dr. Frank's results with xylol and so forth were exactly the same as in those prepared from serum and latex. It would be very interesting to me to have much more information on that point. At least I can confirm the fact that you do obtain protëin reactions which indicate the presence of certain of the products of protëin disintegration, such as tryptophane, which have been mentioned by Dr. Frank.

Mr. GIBSON: In this connection I would like to draw attention to the work of Beadle and Stevens. They made a solution of rubber and allowed it to stand. Most of the insoluble matter settled, and when they took the solution from the top the rubber recovered from it contained little nitrogen and had a poor vulcanising capacity, and gave a very weak product. That at the bottom was high in nitrogen and had a good vulcanising quality.

Mr. STAFFORD WHITBY: Dr. Stevens says that although you get a perfectly clear solution, after allowing it to stand for several months a deposit of insoluble matter occurs. But my experience has not confirmed that. I have kept the solution for a year or more in some cases, and there has been no deposit.

On the Depolymerisation of Raw Rubber.

BY

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It is a well-known fact that there is a close relation between the depolymerisation and the phenomenon of the tackiness of raw rubber. Various external circumstances have been supposed to be the cause of the phenomenon last mentioned, viz.: Sunlight, heat, bacteria, enzymes, faulty coagulation and small quantities of certain chemical substances.

There are two contradictory conceptions concerning the chemical and physical changes which occur in raw rubber when becoming tacky. Several chemists explain the tackiness of rubber as an oxidation process, whilst others believe it is due either to a physical degradation (disagregation), or to a chemical one (depolymerisation) of the rubber. Without discussing fully all researches on this subject, I will quote some of them.

The oxidation theory is specially defended by FICKENDEY, GORTER and KIRCHOF.

FICKENDEY[1] exposed rubber in sealed tubes filled with different gases to the action of sunlight. He observed that rubber in media free from oxygen, such as hydrogen, nitrogen and carbon dioxide, does not become tacky, even after an exposure of several weeks, while rubber in air, and especially in oxygen, has under the same conditions become tacky. From these results, he concluded that oxygen is necessary for the phenomenon of tackiness, and that as a matter of fact the chemical change is an oxidation-process.

GORTER[2] repeated the experiments of FICKENDEY, and could confirm his results. He concluded, after an experimental study of the phenomenon, that the primary cause of the tackiness is due no doubt to an autoxidation process of the rubber; a high degree of tackiness is caused already by small quantities of oxygen. Besides this autoxidation, GORTER supposes still another secondary cause of the tackiness, which he considers to be a change of the degree of dispersity of the colloïd. The very low viscosity of tacky rubber can be explained by this supposition.

KIRCHHOF[3], when studying the oxidation of raw rubber, also concludes that the chemical nature of tackiness is due to an antoxidation process.

As to GORTER'S opinion, the experiments of HENRI[4] on the influence of ultra-violet rays on rubber establish the oxidation theory. HENRI showed that raw rubber in air under the influence of ultra-violet rays soon becomes tacky, which did not occur in evacuated quartz-tubes.

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[1] Fickendey. Zeitschr. f. Kolloidchemie 9, 81 (1911).

[2] K. Gorter. Mededeelingen over Rubber II.

[3] F. Kirchhof. Zeitschr. f. Kolloïdchemie 13, 51 (1913).

[4] V. Henri. Le Caoutchouc et la Gutta-Percha 8, 4371 (1910).

SPENCE, SCHIDROWITZ, and STAFFORD WHITBY consider the tackiness of rubber as being due to its depolymerisation under the influence of the external causes mentioned above.

SPENCE[1] found that small quantities of sulphuric acid caused the tackiness of *Funtumia elastica* rubber; he explained the tackiness as due to a disagregation of the rubber. Though later on FRANK and MARCKWALD[2] supposed the cause of the tackiness of rubber in SPENCE's experiments to be due to faulty coagulation, they agreed with him as to the nature of the process.

SCHIDROWITZ[3] says, when discussing the tackiness of rubber: "The phenomenon of tackiness is certainly not—as was at one time believed—due to oxidation or chemical change, and may be safely regarded as a physical degradation of the rubber substance!" He points out, that tacky rubber always has a very low viscosity in comparison with sound rubber of the same species.

STAFFORD WHITBY[4] believes that tackiness of rubber is due to depolymerisation, which is followed by an oxidation process; in my opinion his experiments are not sufficient to warrant this conclusion.

BERNSTEIN[5] made several interesting researches on the depolymerisation of rubber in connection with a new theory of the vulcanisation process. He found that the viscosity of rubber solutions decreases also under the influence of ultra-violet light, oxygen being absent; this result shows the depolymerisation of rubber in ultra-violet light. He explains HENRI's experiments by suggesting that the principal action of the ultra-violet light has been a depolymerisation; the secondary process is an oxidation of the rubber by ozon just formed.

My researches bear upon the degradation and oxidation of raw rubber in solution of xylene as well as in solid state under the influence of heat. In connection with FICKENDEY's researches I studied the influence of heat on rubber in sealed tubes, containing different gases. It was found that FICKENDEY's results could be obtained also by heating during a short time. When heated for six hours at 130° C. in media free from oxygen, such as hydrogen, nitrogen and carbon dioxide, apparently the rubber did not show any tackiness; on the other hand rubber heated in air, and especially in oxygen, had become tacky.

These results enabled me to study the phenomenon of tackiness with heating experiments. From an experimental standpoint I preferred to study the phenomenon with rubber solutions in a specially designed apparatus; afterwards I confirmed the principal results by experiments with solid rubber. The rubber used was a good quality plantation Para crêpe; the concentration of the solutions in xylene was about 1 per cent., and the temperature at which the experiments were made was 130° C.

The apparatus,[6] which mainly consisted of a pear-shaped glass vessel, was connected with two pairs of HEMPEL's burettes, and complied with the following requirements:

1. With the burettes an absorption of gas could be measured exactly.

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[1] D. Spence. Zeitschr. f. Kolloïdchemie 4, 70 (1909).

[2] F. Frank und E. Marckwald. Zeitschr. f. Kolloïdchemie 5, 189 (1909).

[3] Ph. Schidrowitz. Rubber, p. 135 (1911).

[4] G. Stafford Whitby. Zeitschr. f. Kolloïdchemie 12, 190 (1913).

[5] G. Bernstein. Zeitschr. f. Kolloïdchemie 12, 193 en 273 (1913).

[6] A description of the apparatus will be published ere long.

2. A certain amount of gas could be pressed through the solution, while the total amount of gas in the apparatus remained constant.

3. During the experiments it was possible at any moment to draw a sample of the solution inside, the air being prevented from entering the apparatus. It appeared very soon that oxidation did not occur immediately after starting the experiment. Oxidation which could be detected by an absorption of gas did not begin until after several hours' heating. In some cases the oxidation started after 8 hours' heating, in others not until heating for 10 hours, and a solution of 5 per cent. concentration did not oxidise after 50 hours' heating. When drawing samples I found that the viscosity of the solution decreased considerably. Therefore I could conclude with a fair amount of certainty that primarily a depolymerisation of the rubber solution occurs and that this depolymerisation is followed by an oxidation process.

We now approach the question at which moment the oxidation begins.

Does oxidation occur only when a certain degree of depolymerisation has been obtained? Viscosity measurements showed that the oxidation of various rubber solutions does not start until a definite limit of relative viscosity has been obtained. This critical viscosity-limit is about 1.6—1.3 viscosity-units for rubber solutions of 1 per cent. concentration. More experimental data are required to find the various influences which determine this critical viscosity-limit. From the preceding lines we can explain why different solutions show oxidation after different times of heating. The velocity of depolymerisation depends on the nature of the rubber solution (concentration, preparation, etc.); so we do not wonder that the time of heating wanted to reach the critical viscosity-limit differs with different solution.

After further depolymerisation experiments which were controlled by viscosity experiments, it was found *that the depolymerisation of a rubber solution in an atmosphere of oxygen proceeds much quicker than the depolymerisation of the same solution in an atmosphere of carbon dioxide, though absorption of oxygen did not occur at all in the former case.* From this fact we may conclude that the oxygen has a catalytic influence on the depolymerisation of rubber. Various experiments have confirmed this opinion. When following the depolymerisation in an atmosphere of carbon dioxide I found that the velocity of this process increases considerably when oxygen is admitted to the apparatus. Experiments with other gases, such as hydrogen and nitrogen (free from oxygen) give results identical with those obtained with carbon dioxide.

Since xylene absorbs air to a considerable amount it is absolutely necessary to evacuate the apparatus and remove the air from the xylene by boiling.

Most experiments were confirmed with solid rubber. Various points regarding this question are still under examination. As a result of an extensive number of experiments we conclude:

1. The oxidation of rubber by heat in solution as well as in solid state is always a secondary process, which is preceded by a depolymerisation.

2. The depolymerisation of rubber by heat is catalytically accelerated by oxygen. This acceleration of the depolymerisation by oxygen as catalytic agent must be considered as the primary process causing tackiness of rubber.

3. The results of other researches quoted in this paper may be very well explained from the facts described above.

The CHAIRMAN: We have just listened to a paper on a subject concerning which we have heard a great deal this year. Mr van Rossem's conclusions as to the catalytic action of oxygen in the depolymerisation of rubber are extremely interesting in the light of what we heard from Dr. Helbronner as to the catalytic effect of sulphur in the repolymerisation. I now throw the paper open for discussion.

Dr. WERNER ESCH: I am very glad to confirm all the statements made by Mr. van Rossem in his paper, and may say that another effect which seems to show that his theory of the catalytic influence of oxygen is true is brought about if you add a certain amount of a very strong reducing agent. If you mix tacky rubber with a certain amount of metallic sodium you do away with this depolymerisation very quickly and obtain a very hard and strong rubber, provided that you can remove the last traces of metallic sodium so that it is not effected by moisture. It seems to me that the theory of Mr. van Rossem is confirmed by the effects obtained when such substances as phthalic acid and the like are used to guard against depolymerisation.

Mr. STAFFORD WHITBY: Mr. van Rossem has given us a brief outline of precious researches. I might draw attention to one made by Dr. Gorter, who worked on somewhat similar lines, but with solid rubber. The outline of the work of previous investigators on the question of tackiness and the author's description of his own work make one realise clearly that the trend of opinion is undoubtedly in the direction of the belief that the essential point in the production of tackiness is depolymerisation or disaggregation. In some cases, however, oxidation may follow. It should be made clear that the oxidation is only a subsequent action. It is a physical effect that really gives you tackiness. On the plantation you have tackiness that appears to arise from all sorts of different causes. You have samples which are very sticky and have an extremely low viscosity, and no oxidation occurs at all. But on the other hand there is rubber that, extremely sticky at the beginning, gets harder and harder, and after a year is practically brittle, and virtually is little more than a mass of resin. It may be merely a coincidence, but I found in all samples where the tackiness was followed by a conversion of caoutchouc into resin that a large number of orange spots appeared. I sent a fresh sample along to Mr. Sharples, of Kuala Lumpur, to examine, but, unfortunately, it was not found possible to obtain a culture. It also ought to be recognised that some chemicals may produce tackiness. I found that low grade rubbers, if soaked in caustic soda and then washed out, will in the course of months become extremely tacky. It has also been shown by Mr. Morgan and others that the addition of a minute amount of copper to the latex will produce tacky rubber.

Mr. VAN ROSSEM: I know the researches of Dr. Gorter to which the last speaker has referred. The difference between his opinion and mine is that he thinks it is an oxidation process, and leaves the depolymerisation out of the question. I have already referred to the opinions of Drs. Spence and Schidrowitz. They say that depolymerisation takes place first and oxidation takes place afterwards. I have made a rubber solution in xylene and added sodium to it, and even then in examining the viscosity have not found any increase. That was in solution, but I have not tried it in the solid state.

Dr. ESCH: It is mentioned in a British patent specification signed by Spence and Russell that the rubbers have to undergo a certain kind of incubation process at a temperature of 60° to 100° Centrigrade. I have made the same tests as those just mentioned, and confirm the statement that if you have a solution of rubber in xylene and add an amount of finely divided sodium, and then give it a forty-eight hour incubation, you will perceive that a good deal of the rubber, especially that round the sodium metal, has by that time become a very strong mass, and has become nearly insoluble in xylene. The viscosity of the solution rises very markedly. I have found the whole of the contents of my flask changed into a compact mass of rubber containing xylene. All the results I mention are also mentioned in the patent specifications of Spence and Russell; that in low-grade rubbers a remarkable change comes from only mixing a poor rubber with 5 per cent. of metallic sodium on hot mixing rollers. Although the rubber at first sticks to the mill rolls badly, it later becomes entirely manageable. One more point, not made public in these specifications, is how to remove the excess of sodium. A way exists, but you have to take care that you get away the sodium without rise of temperature, which of course would cause still greater depolymerisation than before.

Mr. VAN ROSSEM: We have not taken the temperatures in these experiments. They may possibly make a difference. I should like to state in reference to what Dr. Bernstein has already told us, that every reaction of rubber such vulcanisation and the formation of bromide derivatives takes place only after depolymerisation. First comes the depolymerisation and afterwards the reaction. That is quite on a line with the results of this paper.

Mr. W. G. MARTIN: I have confirmed all that Dr. Esch has said with regard to Spence's specification and the use of sodium. About four turns were sufficient to produce a piece of rubber like leather to look at. The bother was to get away the excess sodium. We tried washing with water, but after some time we were inclined to think the original tackiness came back again.

Dr. SLOCUM: About a year and a half ago there was an article in connection with the Journal of the Society of Chemical Industry on these lines. In this article Mr. Stanley Peachey described a series of experiments on the oxidation of rubber. He found that acetone extracted rubber was oxidised very quickly, action commencing after 6-8 hours, while the unextracted rubber resisted the action of oxygen until after 78 hours. He ascribed this initial resistance to the action of oxygen to the protective function of the so-called resins. If, however, the primary action of the oxygen is to depolymerise the caoutchouc, would not the determination of the heat of combustion of the sample acted upon give dependable information as to the progression of such a process?

Mr. VAN ROSSEM: My opinion is that while extracting from the rubber Mr. Peachey has depolymerised the rubber to a considerable extent, and that then he has after four hours reached the critical point of oxidation. I suppose this paper may explain Mr. Peachey's results, but in another way.

Dr. SLOCUM: It would seem that by the breaking down of the rubber aggregate by heat, that you would reach the highest degree of reactivity toward oxygen.

Mr. VAN ROSSEM: I have not done any experiments in connection with the heating of rubbers.

Dr. Esch: I need only mention one fact. Does not the deresinification of rubber or gutta-percha always lead to depolymerisation? Dr. Eugene Obach, who was chief chemist with the Siemens Gutta-Percha Works at Woolwich, mentioned in a paper published in 1898 that in their laboratory they extracted the resins from low grade gutta-percha by means of ligröin or petroleum spirit, and that after the content of resin had been brought down to a reasonable figure they could use the extracted gutta as a component of their mixings. These large works are so well acquainted with this kind of manufacture that they certainly would not use this process if there was any subsequent depolymerisation and oxidation in the case of gutta. I would ask the reader of the paper if he has made the same line of tests on gutta or balata mixings? It would be very interesting to know.

Mr. van Rossem: I have only dealt with rubber. I have not given any figures, but can tell you that the work will be published more fully later on.

Mr. W. T. Gibson: I would like to ask Mr. van Rossem to explain a point. He says that the first change is a physical one, and that then comes the oxidation. That does not take place in nitrogen, for instance. If it is first a physical change why should there be a difference between oxygen and nitrogen?

Mr. van Rossem: I have not directly stated that the first action was a physical one. Dr. Schidrowitz has said it in these words: "The phenomenon of tackiness is certainly not—as was at one time believed—due to oxidation or chemical change, and may be safely regarded as a physical degradation of the rubber substances." So that he thinks it is a physical degradation, but others, Spence, for instance, speak about the depolymerisation, and that is more a chemical process. As to my opinion, I prefer the idea of depolymerisation, because there is a chemical reaction. I think that because oxygen is one of the catalytic adjuncts there must be chemical reaction.

Mr. Gibson: The terms depolymerisation and disaggregation are used often, as if they were synonyms.

Dr. Esch: But they are not synonymous.

Mr. Gibson: If the process began with depolymerisation why should there be a difference between nitrogen and oxygen in that respect? Why should rubber depolymerise in the oxygen and yet not in the nitrogen? It is clear from experiments that you can have tackiness without oxidation by simple polymerisation. The reader of the paper takes the view that there must be depolymerisation first, before there can be oxidation. I make the suggestion that has been made often before, that along with the oxidation there may be polymerisation. We do not know exactly what takes place, but there is an intimate change in the molecule which may not concern the whole of the molecule. It causes the tackiness and then the rubber becomes brittle. It has been suggested by Mr. Stanley Peachey that the first oxidation comes with a low percentage of oxygen. Later more oxygen is added, and the material becomes hard, brittle, and resinous. But I have seen his analyses, and these are a good bit out, and never agree very well with theory. It has struck me that when rubber becomes tacky it is really due to depolymerised products, and in with these are resinous products. In course of time the oxidation of the depolymerised products is completed, and then we have an entirely hard body.

Mr. VAN ROSSEM: Mr. Gibson has left viscosity measurements out of the question. I have done these experiments at 130° and have found no oxidation. I can measure in the first place my absorbtion of oxygen to see if there is any oxidation, and afterwards to find if there is any decrease of viscosity. After eight hours I have found that there was not the least oxidation, but the viscosity decreased very much. So I think that we are quite in a position to say, first that there is a depolymerisation, and only after that you get oxidation, not before. I have seen not once but twenty times that when you have rubber solution at 130°, for the first few hours there is no oxidation at all. I have repeated the work for the solid state also at a high temperature, and it oxiziges sooner. As to the reasons why oxygen should act catalytically and nitrogen should not do so, I do not know. There is a difference between these two elements. You cannot say that the reasons for the catalytic reaction of everything are quite known to us. It is a problem that will never be solved. As to the oxidation products dealt with by Mr. Peachey, he has found two oxidation products, and gives the formulæ in connection with them. But what he tells us does not quite exclude that first of all polymerisation takes place.

"Contribution to the Study of Rubber Solutions Vulcanised by the Ultra-Violet Rays."

BY

ANDRE HELBRONNER, Doctor of Science,
And
GUSTAVE BERNSTEIN, Doctor of Science.

The CHAIRMAN : At the beginning of this morning's session we have two papers which are both of very great interest. The first is published under the joint names of Dr. Andre Helbronner and Dr. Gustave Bernstein, and it will be read by Dr. Helbronner. The subsequent one will be delivered in French by Dr. Bernstein. Without any further remarks on the interesting nature of the subject I will announce the first paper, that on " Contributions to the study of vulcanisation by the ultra-violet rays."

Victor Henri was the first, in 1909-1910, to expose rubber to the ultra-violet rays, and he established the fact that under the action of these rays rubber underwent a kind of oxidation.

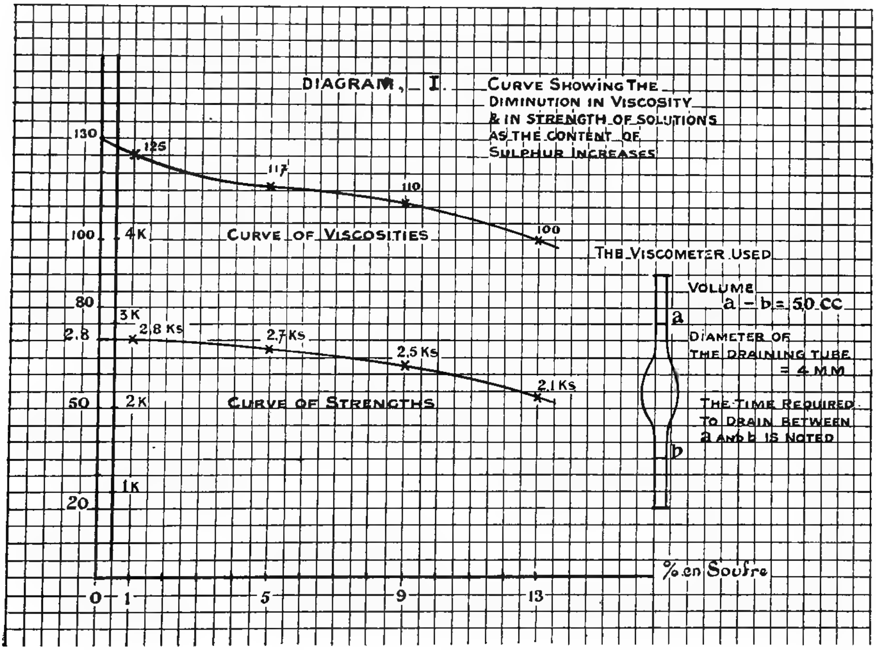
After these tests it was difficult to imagine that vulcanisation by the action of the ultra-violet rays could be effected, all the more because at that time the majority of chemists considered, with Carl Otto Weber, that a true chemical combination took place between sulphur and rubber, with formation of a series of addition products ; and it, therefore, meant a reaction of the massic order, requiring a very prolonged photochemical action ; experience, however, corrected this view, and the rapidity of photochemical vulcanisation revealed the catalytic nature of the reaction between sulphur and rubber.

The vulcanising tests were carried out with films and solutions of rubber. A solution of rubber containing sulphur when submitted to the photochemical rays became so thick that it was transformed into a gelatinous mass of " fluid rubber." At the same time it was found possible to detect, by chemical tests, the formation of combined sulphur. The experiment, therefore, showed that it was possible to obtain a vulcanised solution, although vulcanised rubber is insoluble.

PREPARATION OF THE SOLUTION.—The solutions we exposed to the ultra-violet rays contained, according to circumstances, from 1 to 5% of rubber. We chose the two most common varieties, viz., Ceylon and Pará. The solutions generally contain about 6% of rubber, and if, in this case, the rubber has not previously been passed through the rolls it will form a thicker and less homogenous solution. Therefore, it is necessary to work up the rubber before dissolving it. The solution obtained is much more fluid, but in consequence of the depolymerisation of the rubber used it has less resisting qualities. In case, however, it is not convenient, as will be seen further on, to obtain a concentrated vulcanised solution, one can use rubber that has not been milled and which has lost none of its natural properties. It may be noted, also, that after vulcanisation by the ultra-violet rays one recognises a perceptible difference between the degree of resistance of the prepared rubber and that not prepared; for instance, a solution containing 2% of unworked Ceylon rubber gave 2·1 kilos. of resistance before treatment with the rays, and 12.5 kilos. afterwards, whereas a solution containing 2% of thoroughly worked Ceylon rubber gave 0·8 kilo. before, and 8·2 kilos. after.

A solution of 2% Ceylon rubber thoroughly rolled, but repolymerised by having been stored several months, gave 1·9 kilo. before and 9·5 kilos. afterwards.

The sulphur used for making the solution is soluble sulphur, *i.e.*, it is not well to use either "flowers of sulphur" or stick sulphur, which is to a great extent insoluble. Crystals of sulphur may be used with advantage. Sulphur has, it is true, the effect of diminishing to a small degree, the viscosity of the solutions.



The curve shown in Diagram 1, demonstrates the manner in which the viscosity of a solution varies as the contents of sulphur varies. The viscosity of a solution without sulphur being 130, whilst those with 1%, 5%, 9% and 13% of sulphur become respectively 125, 117, 110 and 100. On the other hand, by measuring the tensile strength by means of an apparatus which we will briefly describe later on, we get, for solutions containing 0%, 1%, 5%, 9% and 13% of sulphur, the figures 2·8 kilos., 2·7 kilos, 2·5 kilos. and 2·1 kilos, which diminish in a manner analogous to the diminution in viscosity.

The solutions are exposed to the ultra-violet rays by means of certain apparatus, many forms of which have already been proposed for the purpose of exposing opaque fluids to the action of the rays in thin layers. All the instruments in question may be employed, with certain modifications, which depend on the viscosity of the fluid with which we have to deal. Diagram (No. 2) shows the apparatus for exposing the fluid to the rays; the solution is poured into a hopper T which throws it by means of an adjustable shutter t on to a cloth A, which moves on rollers R R′, and thus passes before the quartz mercury lamp L, surrounded by a refrigerating mantle M made of quartz with water circulation; the vulcanised solution is then scraped off with a knife U and falls into the collecting dish V.

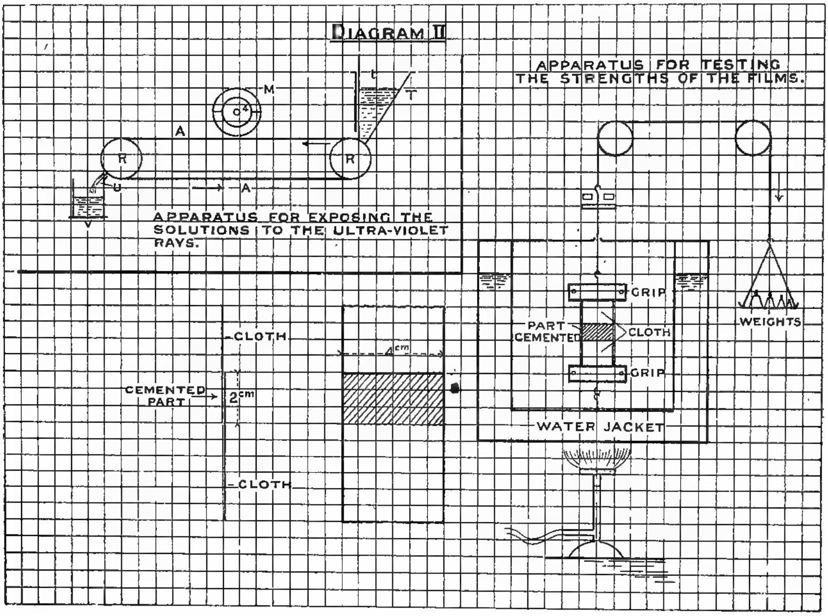
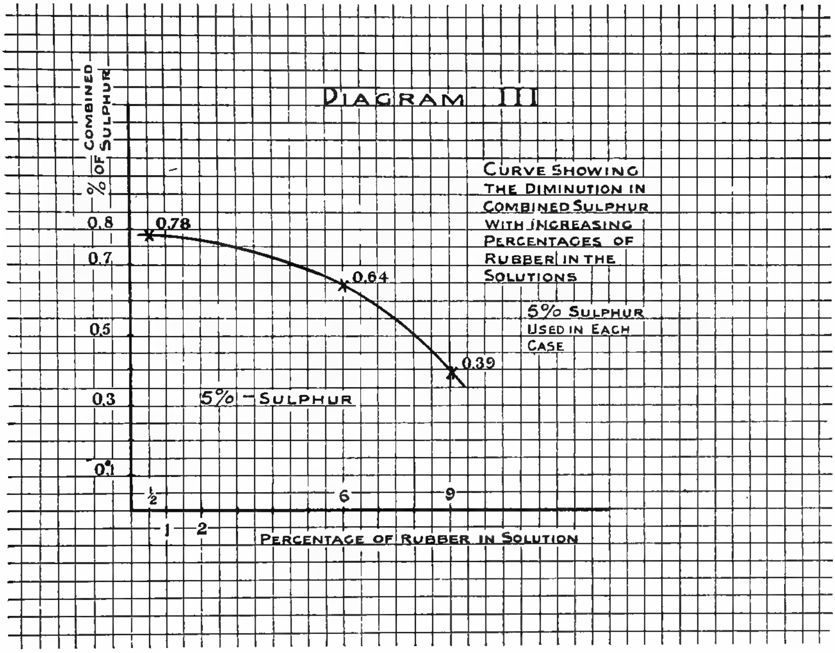


DIAGRAM II
M
L
t
T
A
R
R
U
A
V
APPARATUS FOR EXPOSING THE SOLUTIONS TO THE ULTRA-VIOLET RAYS.
APPARATUS FOR TESTING THE STRENGTHS OF THE FILMS.
GRIP
PART CEMENTED
CLOTH
GRIP
WEIGHTS
WATER JACKET
CLOTH
CEMENTED PART
2cm
4cm
CLOTH

Our first care was to find a way of diagnosing the vulcanised solutions thus obtained. Measuring the degree of viscosity by running it into a calibrated tube, which is excellent under ordinary conditions, is impracticable here, because the vulcanised solutions constitute an elastic mass of fluid rubber, of enormous superficial tension. The method of dropping a marble on the surface of the liquid did not give satisfactory results. Sulphur determinations are equally difficult of application, the small quantity of sulphur in combination not permitting a sharp comparison, though we frequently used this method. We employed a direct test, consisting of measuring the cement strength of the different vulcanised solutions under exactly identical conditions. The testing instrument (plate 3) consists of two claws gripping two pieces of fabric cemented together by means of the solution to be tested. This cementing together is always done in exactly the same way, on a given surface

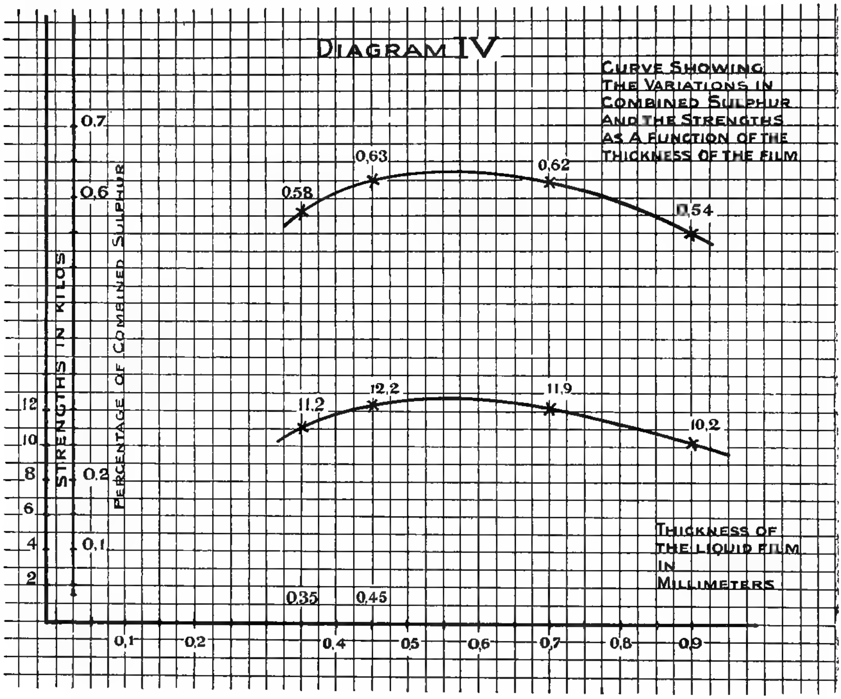
(6 square centimetres). One claw is fixed to a hook placed at the back of a drying stove and the other to a cord passing over a pulley and carrying a plate on which are placed progressively the weights up to the breaking point, at which moment the total weight expressed in kilogrammes constitutes the degree of resistance to separation of the plies. For the most part our tests were carried out with the stove heated to 80/85° for 30 minutes.

We will now consider the different factors which aid in obtaining a good vulcanised solution.



The curve shown on Diagram 3 shows the variations in combined sulphur as a function of the concentration of the rubber solutions. The different solutions used contained 5% of sulphur and rubber varying in quantity from ½% to 9%. As will be seen, the quantity of combined sulphur varied very little up to the 6% of rubber, but after that it diminished very rapidly. The thickness of the layer exposed to the ultra-violet rays has been determined theoretically for different solutions by means of the spectrograph (the solutions being of Ceylon, Pará, Massai rubber, etc.). The thickness to be adopted varies naturally with the colour of the rubber used; for example, with crepe from Ceylon, which are lighter in colour, one can use a much thicker layer than with Congo rubber. The thickness of the layer must be very little less than 1 millimetre; with thinner layers of one of the most important rays of the ultra-violet spectrum of mercury (Λ = 2,749 Angstrom units) is not absorbed.

Besides, it may be noted that spectrography does not give an exact indication as to what is the best thickness; in fact, the ultra-violet radiation does not act except in so far as it is absorbed by the liquid under treatment ; it is necessary, therefore, to have the thickness considerably greater than that indicated by the spectrograph. On our part we always worked with a layer 40% thicker than indicated by the spectrograph.



The curves shown on Diagram 4 indicate the quantity of combined sulphur as related to the thickness of the liquid film for a 10% solution of Ceylon rubber. With layers of 0·35, 0·45 and 0·70 mm. the cementing power is nearly constant (11·2, 12·2 and 11·9), but on increasing the thickness it falls to 10·2 for a layer of 0·9 mm. The quantities of combined sulphur for the thicknesses given above are 0·58, 0·63, 0·62 and 0·54 gram., and these correspond exactly with the strength results given above.

It was then necessary to determine the speed of vulcanisation by the ultra-violet rays. This vulcanisation process consists of a depolymerisation of the rubber, followed by a repolymerising action due to the sulphur, and the final product is the resultant of the two opposing factors.

The two curves on Diagram 5 show clearly the stages of the phenomenon ; it will here be seen that in 7 seconds the rubber without sulphur is completely depolymerised, whilst when sulphur is present not only is there no depolymerisation, but on the contrary there is a progressive repolymerisation. When the length of the exposure is increased the vulcanised product becomes depolymerised in its turn, the depolymerising action of the ultra-violet rays becoming greater than the polymerising action of the sulphur. It is only necessary to glance at the two curves on Diagram 5 to follow the successive stages of the phenomenon.

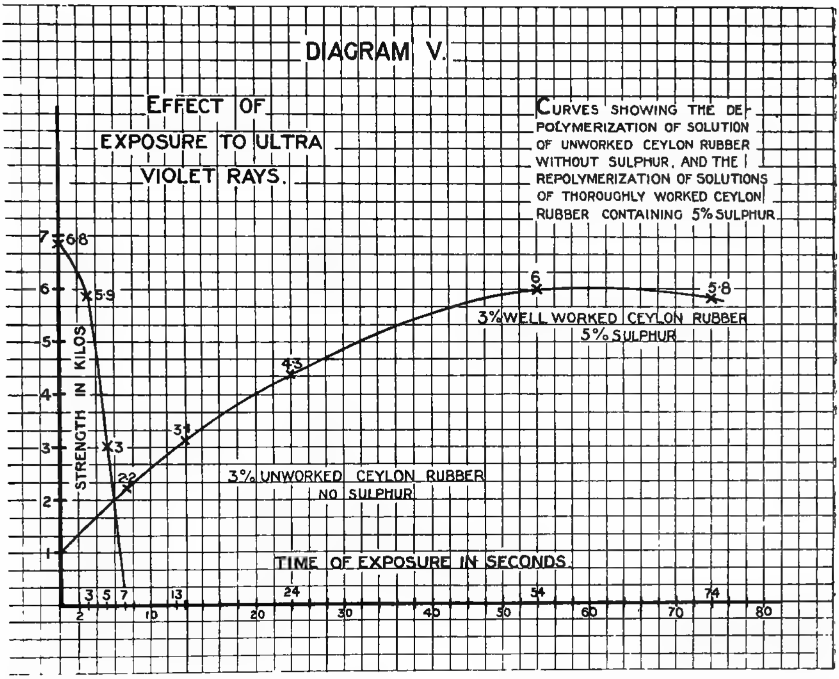


DIAGRAM V.
EFFECT OF EXPOSURE TO ULTRA VIOLET RAYS.
CURVES SHOWING THE DEPOLYMERIZATION OF SOLUTION OF UNWORKED CEYLON RUBBER WITHOUT SULPHUR, AND THE REPOLYMERIZATION OF SOLUTIONS OF THOROUGHLY WORKED CEYLON RUBBER CONTAINING 5% SULPHUR.
STRENGTH IN KILOS
1
2
3
4
5
6
7
6.8
5.9
3
2.2
3.1
4.3
6
5.8
3% WELL WORKED CEYLON RUBBER 5% SULPHUR
3% UNWORKED CEYLON RUBBER NO SULPHUR
TIME OF EXPOSURE IN SECONDS
3
5
7
13
24
54
74
2
10
20
30
40
50
60
70
80

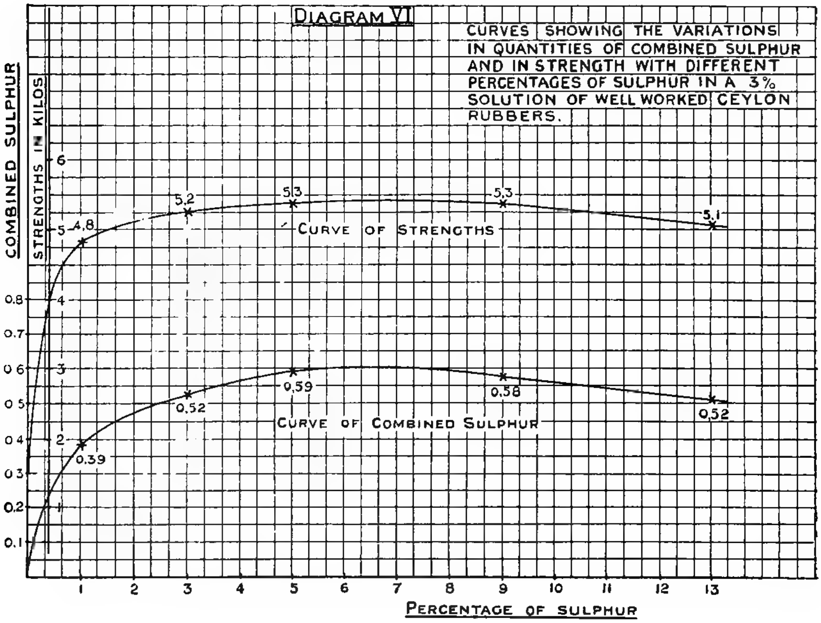


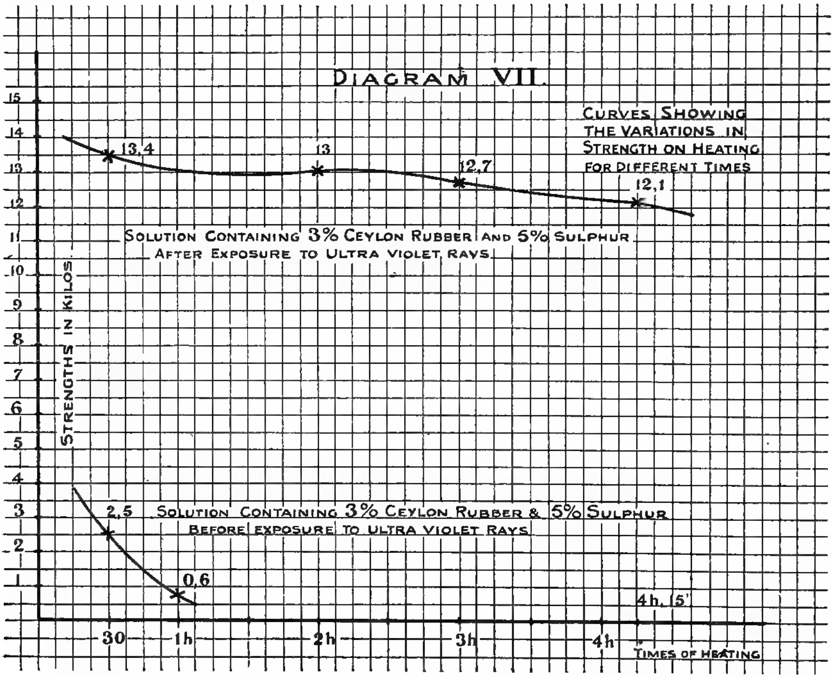
DIAGRAM VI
CURVES SHOWING THE VARIATIONS IN QUANTITIES OF COMBINED SULPHUR AND IN STRENGTH WITH DIFFERENT PERCENTAGES OF SULPHUR IN A 3% SOLUTION OF WELL WORKED CEYLON RUBBERS.
COMBINED SULPHUR
STRENGTHS IN KILOS
6
5
4
3
2
1
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
4.8
5.2
5.3
5.3
5.1
CURVE OF STRENGTHS
0.39
0.52
0.59
0.58
0.52
CURVE OF COMBINED SULPHUR
1
2
3
4
5
6
7
8
9
10
11
12
13
PERCENTAGE OF SULPHUR

We then enquired into the quantity of sulphur which it was preferable for the solution to contain. We varied this up to 13% of the weight of the rubber, and we found that there was a maximum percentage which should not be exceeded; the figures for the strength and for the combined sulphur, instead of increasing, immediately decreased after this point. The curves shown on Diagram 6 show this action. The proportion of sulphur varies naturally according to the nature of the rubber employed, and there are even perceptible differences between the Ceylon and the Pará species.

The vulcanised solutions are permanent. We have had them under observation for 6 months without change. It must be noted, however, that if the exposure to the ultra-violet rays is too rapid the vulcanising action of the sulphur or the repolymerisation of the rubber continues after the exposure to the rays has ceased. It is for this reason that a solution giving a strength of 18·4 kilos., after an exposure of only a few seconds, will, after a lapse of two months, show a higher figure, viz., 22·3 kilos. The solutions vulcanised under the most favourable conditions did not give us such important variations. With one of these solutions we obtained the following nearly equal figures:—

31/1/14	.. .. ..	18·6 kilos.
12/4/14	.. .. ..	19·4 „
14/4/14	.. .. ..	19·5 „

These vulcanised solutions are suitable for all kinds of cementing or "rubberizing" operations, and are capable of resisting all mechanical strains, as well as the action of heat.



The curves given in Diagram 7 show the strength tests for two solutions, one vulcanised by ultra-violet rays, the other not; the strengths being shown as a function of the time of heating, the one before and the other after exposure to the ultra-violet rays. In the case of the first, the non-vulcanised solution, the temperature was 80° and the tearing point 2·5 kilos. after 30 minutes heating and 0·6 kilo. after 60 minutes. The second solution, which had been exposed to the ultra-violet rays, gave 13·9 kilos. after 30 minutes heating and 12·1 kilos. after 4 hours heating, a difference which needs no comment.

Besides the operations of rubberising cloth, these vulcanised solutions are suitable for sticking together all kinds of rubber tissues. They will be found useful in numberless ways in the making of waterproof garments. They can be used equally well for the joining and for rubberising of leather ; and consequently will be most valuable in the shoe industry.

Lastly, the repairs of all rubber goods (tyres, tubes, etc.) can be perfectly carried out by means of vulcanised solutions, and in view of the many purposes for which they will serve one may predict for them a brilliant future.

As regards the joining of two pieces of rubber, experiments have brought out an entirely new way of effecting this. At present the method is to spread one or more layers of solution containing 6% to 12% of rubber on the surfaces of the parts to be joined ; after evaporation of the solvent a thick film is formed, and if the two pieces are pressed together at once a layer of rubber is formed between them which should be able to resist all strains to which they might be submitted.

By using the vulcanised solution of an altogether different concentration (0·5% to 1%) a positive absorption of the solution is obtained, and the two pieces to be joined are no longer separated by a layer of rubber ; they are in immediate contact, and penetrate one into the other.

With ordinary solutions the separation is effected in the intermediate layer ; with vulcanised solutions the separation is obliged to follow the sinuosities of the two surfaces which have been joined. Experience has shown that this tearing is exceedingly difficult to bring about.

By using these vulcanised solutions one obtains not an ordinary join, but a true autogenous rubber welding.

The Chairman : In the first place I think we all owe a debt of gratitude to Dr. Helbronner for his courage in reading his paper in English. I sat there while he was doing it, and imagined myself trying to read a paper before a French audience in the same way. I need not call your attention now to the extraordinary interest of the paper. I think you will agree with me that as Dr. Bernstein's paper follows on so closely, and is so closely related, it will be much better for us to go on with it before there is any discussion at all. Before he reads his paper, which he will have to do in French, it will be just as well if I say a little about his conclusions as stated at the close. You will have seen that in Dr. Helbronner's paper one of the important points has been the view of the vulcanising reaction shown in the two curves, the first a complete and phenomenally rapid depolymerisation, and then what he calls a repolymerisation under the catalytic action of sulphur. Dr. Bernstein's paper follows that out, and deals particularly with the matter of vulcanisation and the nature of that reaction as bringing into comparison the conclusions of other experimenters.

Vulcanisation.

By

GUSTAVE BERNSTEIN, Doctor of Science (Clermont-Ferrand.)

Manager, Torrilhon Works.

In my first experiments on the vulcanisation of rubber by cold cure with chloride of sulphur, I proved that the presence of traces of chloride of sulphur diminished suddenly the viscosity of rubber solutions. I noticed the same diminution of viscosity on adding traces of bromine. The viscosity of rubber solutions in presence of traces of these bodies became almost equal to the viscosity of the solvent alone. The quantities of chloride of sulphur and bromine added were too insignificant to account for this diminution by a lowering of the concentration of the rubber solution resulting from the addition of the latter. What happens here is a phenomenon exclusively physical, a depolymerisation of the rubber, a passing from $(C_{10}H_{16})^n$ to $^nC_{10}H_{16}$.

The viscosimetric method applied by us for the first time to the study of vulcanisation was adopted afterwards by Mr. Kirchoff, who, on repeating my experiments, obtained the same results, and came to the same conclusions.

Rubber must be depolymerised before it can enter into reaction. This explains why the oxidation of rubber is helped by heat, work, or light, all of which depolymerise it.

I have studied this depolymerisation by means of viscosimetric measurements. The rubber was worked for a certain length of time on the mixer ; at regular intervals, samples were taken which gave solutions that gradually decreased in viscosity.

The same observations were made with films of the rubber heated progressively out of contact with the air. On exposing rubber solutions to ultra-violet rays, it is found that the viscosity decreases with the duration of the exposure. Through the agency of heat, mechanical work, or light, I have obtained after complete depolymerisation the same degree of viscosity in solutions prepared with different kinds of rubber. Thus Para, Madagascar, Massai and Castilloa all completely depolymerised, have the same viscosity, which approximates to that of the solvent alone.

All the physical agents that bring about the depolymerisation of rubber cause a vulcanising action on the latter when it is mixed with sulphur. For example, a rubber solution mixed with sulphur and exposed to the action of the ultra-violet rays thickens considerably, and is transformed into a gelatinous mass. Vulcanisation takes place and sulphur enters into combination. This is my conception of the new process of vulcanisation by actinic light.

There is, then, reason to believe that heat or light depolymerise rubber, which, thus rendered capable of combining with sulphur, is repolymerised by the action of the latter. The vulcanisation appears, then, as the result of a previous depolymerisation of the rubber with a subsequent repolymerisation under the action of sulphur.

One fact among others confirms this opinion. A mixing made for rapid vulcanisation will partially vulcanize on the rolls of the mixer, although the temperature of the rolls does not exceed 80° C. In such a case I have found as much as 0·8% of combined sulphur in the milled mixing. On heating the same mixture in an oven to 80° C. for the same length of time as given on the rollers, I could not find a trace of combined sulphur. The inference is that mechanical work in assisting the depolymerisation of rubber brings about vulcanisation.

When studying, in collaboration with Dr. A. Helbronner, the vulcanisation of rubber solutions by actinic light, I ascertained that these vulcanised solutions are remarkably stable. After several months it is impossible to discover in them the least trace of precipitation even after 18 hours heating at 80° C. The amount of combined sulphur required to obtain a well vulcanised solution is small, and does not correspond with the usual proportions found in ordinary vulcanising processes. The latter requires 1·5 to 2·5% of combined sulphur in the vulcanised solutions, while in the case we are now considering we obtain, on evaporation, a residue possessing all the characteristics of a good vulcanisation, but containing only 0·6% of combined sulphur.

The vulcanising action of this small quantity of sulphur may be compared with the polymerising effect of traces of sulphur (0·2%) in the syntheses of rubber from isoprene by the Badische Anilin process. The rubber obtained by this synthetical process is polymerised to a greater degree than natural rubber; and similarly I have ascertained that the addition of traces of chloride of sulphur promotes in the same way the condensation of isoprene into rubber under the action of heat or light. The rubber obtained is more polymerised than the natural produce.

From these studies I drew the following conclusion:—Vulcanisation, or, as I regard it, the repolymerisation of rubber, can be effected by the presence of quantities of sulphur much smaller than that required by the ordinary processes of vulcanisation.

It appears, then, that the amount of combined sulphur (the "coefficient of vulcanisation" of C. O. Weber) does not serve as a measure of the degree of vulcanisation unless the physical conditions are kept absolutely constant.

Besides, the variation in the amounts of combined sulphur, and the variety of physical properties obtained in vulcanisation, seem to point out that the repolymerisation of rubber by sulphur, which takes place in the second phase of vulcanisation, is a catalytic reaction, and that the combination of sulphur with the rubber is only a subsidiary and secondary reaction.

There remains still another very interesting point to establish: that is, the nature of the combination of sulphur or chloride of sulphur with rubber during vulcanisation. Until now this point has been wrongly considered as the most important one, and to many authors it meant the whole problem of vulcanisation.

As to chloride of sulphur, I have already ascertained in my previous experiments on cold vulcanisation that it is a pure addition reaction.

The product resulting from the action of an excess of chloride of sulphur upon rubber in solution contained a proportion of chloride of sulphur corresponding to the formula $(C_{10}H_{16})\,2S_2Cl_2$, this product having been isolated for the first time by Hinrichsen and Kundscher.

As to the combination of sulphur with rubber, the question seems to be solved by the most recent work of Spence and Hinrichsen. According to these authors, this is also an addition reaction. On the other hand, an experiment made by me to ascertain whether the formation of combined sulphur takes place according to the adsorption theory of Oswald, has given results rather in opposition to that theory. The experiment consisted in adding to the latex a colloidial solution of sulphur in water; the rubber and sulphur are then in the most favourable physical condition for combination by adsorption. In order to fix the dimensions of the globules of rubber, we have prepared artificial latex. It is easy to pass, by coagulation, from latex to rubber, but the reverse process, so far as I know, has never been done before. The method was as follows: I dissolved some rubber in monochlorhydrin, and poured the solution into water, shaking it violently. Meanwhile, the monochlorhydrin being soluble in water, the rubber precipitates in the colloidial state, and a milky emulsion is formed; the size of the rubber globules depends upon the violence of the agitation. The intermediary solvent is eliminated by dialysis. To this solution of artificial latex we add sulphur in colloidial solution, the latter being prepared according to P. Von Weinmarn's method as follows: Prepare a saturated solution of sulphur in pure alcohol and pour it into water, the alcohol being miscible with water, the sulphur precipitates in form of a colloidial emulsion, the alcohol is eliminated by dialysis. In mixing these two colloidial solutions I could not detect any combination of sulphur with rubber.

From this sketch of my researches on the vulcanisation of rubber, I draw the following conclusions:—

1. In the vulcanisation there is first a depolymerisation of rubber, with subsequent repolymerisation under the action of sulphur.
2. C. O. Weber's co-efficient of vulcanisation does not allow any measure of the degree of vulcanisation unless the physical conditions during vulcanisation are absolutely the same in each case.
3. The repolymerisation of rubber by sulphur is a catalytic reaction. The combination of sulphur with rubber is only a subsidiary and secondary reaction.
4. This reaction is chemical in cold cure, and leads to a definite product. In vulcanisation by heat or light the question is not definitely settled. However, the formation of combined sulphur does not take place by adsorption pure and simple of sulphur by rubber, according to Oswald's physical theory.

The CHAIRMAN: Dr. Helbronner wishes me to mention that any of us who like to look at his apparatus may do so at an address he mentions, this afternoon. We have all been accustomed to the idea of certain light effects on rubber. I suppose the one that has gone out most widely, outside strictly scientific circles, is the well-known effect that light has been known for years to have on sheet rubber, the exposed parts being affected differently from the rest. We have known that light had some sort of changing effect just on the surface of pure sheet rubber. The action of light has also been taken advantage of in connection with photo-lithography. Those of us who work in laboratories have doubtless had the curious experience of having made rubber in a solution of petrol and then, after its exposure to the light for some time, seeing the rubber come down as oil, and refuse to come down in its ordinary condition. But to me the idea that has been expounded this morning, as bearing on this matter of vulcanisation, and the view of the reaction in this particular case and in that particular kind of vulcanisation, is a new one. I think there will probably be a great many questions. I may first mention that we are honoured by the presence of Sir William Ramsay this morning, and perhaps we will have the pleasure of hearing some expression of opinion from him.

Sir WILLIAM RAMSAY: I am really an ignoramus about rubber, but there is one interesting point which occurs to me in connection with these papers, and that is that Messrs. Bernstein and Helbronner have demonstrated what is the usual course of events in connection with discoveries. What happens is that the practical man makes a discovery and uses it for a long time, and no one knows why this discovery works, and later on the scientific man takes it up, and in the long run no doubt greatly improves the practice of the practical man. I think it is the evolution we are seeing at the present moment. I would like to ask Dr. Helbronner whether he has made any calculations as to the molecular weight of the rubber? I have made a rough calculation, taking as a basis some of the data given by Dr. Helbronner. Assuming that the figures given by him, $C_{10}H_{16}$, are correct and that one polymeride of rubber took up one atom of sulphur, then the molecular weight would be 40 times $C_{10}H_{16}$, so that the total molecular weight would be 5540. Although I am making the conclusion that one of these polymerides of rubber took up one atom of sulphur, it might require more. It might be that two or three of the latter were combined. The molecular weight as estimated is extremely high. I have no doubt that conclusions of this kind will throw much light on the amount of polymerisation of rubber, and I have no doubt that we will be able to produce the varieties of rubber by allowing the polymerisation to go on, and then stopping it at a certain point. One thing I should like to know is, do these solutions show permanence or do they lessen in viscosity as they go on? Is it a fixed thing in solution or continually changing? I have listened with admiration to the papers of Dr. Helbronner and his colleague, and think they will throw a greater light on the solution of rubber chemistry than it has ever had before.

Dr. HELBRONNER: I must thank you very much, Sir William, for coming here this morning, and I will answer your questions at once. In dealing with the molecular weight of the rubber, I would like to know, what is India-rubber? I do not think you can take a sample and say "This is India-rubber and this is the molecular weight." With my ideas of polymerisation I think there are many different rubbers. The degree of the polymerisation of rubber is not the same in Eastern as in Para. If I calculate the molecular weight for one sample it will not be the same for another. As a matter of fact, this question of polymerisation must not be applied only to the gutta rubber, but it must be applied to all the many complicated substances. I think for my part that in polymerisation we can go not merely step by step, but we can jump. I do not think, to be quite candid, that it is necessary to calculate the molecular weight of India-rubber. I think we can do it, but I do not consider it necessary. With regard to another question that was asked by Sir William Ramsay, I can tell you the viscosity of the solution I have made after one month, or two or three. After eight months it differs very little. During the first fortnight it decreases a little, and after that it is practically constant. I had the pleasure of meeting Sir William Ramsay in Paris a few weeks ago in connection with the question of the unification of chemico-physical units, and I think it would be very interesting to make the unification for viscosity also. Dr. Schidrowitz, for instance, has been working in London with this object in view.

Mr. B. D. PORRITT: I think one of the most interesting points is as to the stability of the cells under the influence of sulphur. A few years ago, working from a practical point of view, we tried the effect of adding sulphur chloride to a solution of rubber, and the result was a remarkable one. It was done roughly, and I do not know the figures. The first effect was absolutely *nil*, and the solution, as far as one could judge, was exactly the same. I thought this remarkable, and in a quarter of an hour went back and shook it, with the result that it immediately set in a jelly. I put it on one side, and after a time the solution darkened, the inorganic matter settled down, and viscosity set in. I did not proceed with the work at all. I would like to know whether the other gentlemen have had any similar experience.

The CHAIRMAN: There was no definite treatment with cold cure solutions mentioned in the paper.

Mr. P. J. BURGESS: The readers referred to the different viscosities of solutions made from different varieties of plantation rubber and Para wild rubbers. When depolymerised you get a solution which has equal viscosity, or more; when it is further repolymerised do you get varying viscosity according to the quality of the rubber?

Dr. HELBRONNER: I told you the viscosity determinations. I have tried several methods, the method by which viscosity is determined by the time that a given volume requires to run from a tube, such as is shown in my diagram, and others.

Mr. BURGESS: Have you made any attempt to ascertain whether the solutions which are supposed to have reached the same degree of vulcanisation actually contained the same amount of combined sulphur?

Dr. HELBRONNER: I have no indication. The percentages of sulphur to be determined are very small. I have obtained different solutions with about the same quantity of combined sulphur. Up to now I am looking for other methods.

Mr. BURGESS: Does it vary?

Dr. HELBRONNER: No, I am getting good indications. The measure of the chart of rupture is according to me the sole measure which gives me a pretty good idea of the quality of the vulcanised or unvulcanised solution.

Mr. BURGESS: How do you find that applies to the origin of the rubber?

Dr. HELBRONNER: We used Fine Hard Para rubber and Ceylon crepe. If I took a solution of Ceylon and one of Para and vulcanised them with the same quantity of sulphur, with Para I got a chart of rupture of 14·8, and with Ceylon of 12·1. I repeated these experiments about six or seven times, and always found the same difference.

The CHAIRMAN: Suppose you take two solutions, one of Para and the other of Ceylon, and you depolymerise both perfectly. Then you begin to repolymerise. At the maximum will the Para curve be higher than the Ceylon curve?

Dr. HELBRONNER: Yes. With Ceylon the strength is 4 kilos, but the Para strength will be 5 kilos.

Dr. SLOCUM: Will your second curve of Para and Ceylon be the same?

Dr. HELBRONNER: No, it will not be the same. You find the same corresponding difference.

Mr. W. T. GIBSON: The suggestion has been made that depolymerisation is the first stage under the action of the ultra-violet rays. I am not going in to that question, but the authors have stated that the increased viscosity that ensues is due to the repolymerisation of the rubber. There is, however, another possible explanation. It is that the sulphur compound which has been formed has a high viscosity. I would like to know whether this has been considered. The authors claim that if the rubber and sulphur are in solution together and exposed to the ultra-violet rays, first of all a depolymerisation takes place, followed by a repolymerisation. Now, with regard to the second point of the process, the so-called repolymerisation, I put forward another suggestion, that the viscosity of the sulphur-rubber compound is high, and as more of it is formed the viscosity of the solution increases. Therefore, if that is the case, it would not be right to say that there was repolymerisation of the rubber just because of the viscosity of the solution increasing. I do not say that is an explanation, but I do put it forward as a point that should be considered. With regard to another point, the authors mentioned the catalytic effect of the rays. I do not understand.

The CHAIRMAN : The catalytic effect of the sulphur.

Mr. GIBSON : I understand now. With regard to the fact that the sulphur rubber compound remains in solution, have the authors considered the possibility that the sulphur compound is in this solution in a molecular state, and that the dispersion has increased so far that there are free molecules of rubber and sulphur in the solution. The fact that the solution is so stable is rather in favour of that idea. Then there is another point not mentioned in the paper. In the " Zeitschrift für Kollöide " there is an article by Professor Ostwald to which a footnote is attached asserting that Dr. Bernstein has revised his views regarding the theory of vulcanisation, and it is clear from what Dr. Bernstein has told us to-day that he has not done so. I should like to know how the misunderstanding has arisen.

Dr. HELBRONNER : In answer to that question I may state that Dr. Bernstein and Professor Ostwald differ just as much to-day in their theories of vulcanisation as they did a year or two ago. I think for my part that the theory of Professor Ostwald is a mere theory. A theory must be the consequence of experiments, and before Dr. Bernstein spoke to you I told you of old experiments that I had done. We did not print our theory of vulcanisation before I had made these experiments. When I have seen that the co-efficient of vulcanisation by the ultra-violet rays is only 0.6, 0.5, 0.4 per cent., I can assume that it is a catalytic reaction, and I can assume that there is no molecular reaction. When I say it is real repolymerisation I am entitled to say that, because it is a consequence of experiments. In the theory that I have exposed and that Dr. Bernstein has exposed we are only drawing conclusions of the results of experiments. It is no mere theory, but a general interpretation of the facts.

Mr. GIBSON : My point is, has the other possible interpretation been considered ? Would you say it is impossible ?

Dr. HELBRONNER : I do not draw any definite deduction for the vulcanisation generally speaking. I have seen certain points and Dr. Bernstein has seen them with me. If you wish to apply it to vulcanisation in general you can do it.

The CHAIRMAN : All the claim that has been made is that a solution of the question of depolymerisation and repolymerisation has been arrived at in this way. It is not claimed that it can be applied to general vulcanisation. I would like to ask Mr. Gibson one thing, whether he has taken into account the peculiar form of repolymerisation curves. They go to a maximum and then drop again. How do you account for the drop in the curve by concentration ?

Dr. HELBRONNER : Because the repolymerised product under the action of the ultra-violet rays is submitted to a further depolymerisation.

The CHAIRMAN : Now let us follow it on your lines.

Mr. GIBSON : That the increase is due to the formation of the rubber sulphur compounds.

Dr. HELBRONNER : If there is a real rubber sulphur compound !

Dr. SLOCUM : With regard to Dr. Bernstein's curve of vulcanisation, it follows the general law of combination of two substances under catalytic action. Such reactions are always reversible. Twitchell himself has shown that an increase of his reagent to 50 per cent. of the mixture will cause the formation of glycerides from glycerine and fatty acids, instead of the hydrolysis usually observed. The action of increasing amounts of acid catalysts in mixtures of acids and alcohols follows the same law. Therefore, does not this look like a caoutchouc-sulphur combination rather than polymerisation ?

Dr. HELBRONNER : The light is not the catalyser. I have shown that the sulphur becomes insoluble ; sulphur thus unites with the India-rubber. On the one hand a certain action of the rubber is caused by the ultra-violet rays, and another by the sulphur, and those two combined actions produce the vulcanisation, but the light itself is not a catalyser. The ultra-violet rays cause the action of the catalyser.

Dr. SLOCUM : Light can act as a catalyser. We know that.

Dr. HELBRONNER : In this instance it is not a catalyser. Sulphur becomes the catalyser under the action of the light.

Dr. LOEWEN : You have not told us that the sulphur becomes insoluble by the action of the ultra-violet rays, but it seems to me probable that when evaporating a solution of rubber and sulphur exposed to these rays a part of the sulphur is not to be extracted from the product. It seems to me that the authors have not proved that there is any chemical combination, or any combination at all. That there is an increase of viscosity is not to be doubted, but while one may call that polymerisation I should not like to call it vulcanisation.

Dr. HELBRONNER : I do not say my sulphur is chemically combined, but, according to the theory of Dr. Bernstein, whether the sulphur is physically or chemically combined it is quite satisfactory. The great question is to determine the nature of the vulcanisation, which, according to our ideas is a mere polymerisation of the rubber under the action of a catalytic agent (sulphur).

Dr. LOEWEN : I think this is a matter of very great importance. In my opinion the chemical combination of sulphur is a necessary condition of the appearances which are known as vulcanisation. I am thinking of analyses which have been made, by Dr. Spence, for instance, of products which contained 32 per cent. of combined sulphur. This may certainly be described as a chemical combination.

Dr. HELBRONNER : I made about 100 analyses. If I make an analysis and draw out the acetone I am drawing out the sulphur not combined, but not the combined sulphur. You have the same thing in every analysis of rubber.

Dr. LOEWEN : Yes, in every analysis of rubber I extract uncombined sulphur with acetone.

Dr. HELBRONNER : And you do not extract the combined sulphur. I can tell you that because with a special washing after the extraction with acetone I obtained always some combined sulphur. Moreover, I have obtained India-rubber films containing 2 per cent. and 3 per cent. of combined sulphur.

Dr. LOEWEN: It is true that one can get vulcanised products with much higher quantities of combined sulphur.

Dr. HELBRONNER: With this method?

Dr. LOEWEN: In others.

Dr. HELBRONNER: I am dealing with this method, and not with other methods. I can obtain 2·5 per cent. of combined sulphur extracted by the ordinary methods.

Dr. LOEWEN: I am not yet persuaded——

Dr. HELBRONNER: You can do it easily yourself. Take an India-rubber film and expose it to the ultra-violet rays for about ten minutes. Then you get a film containing about 2½ per cent. of combined sulphur. It is a question of experience. Repeat these experiments. In science you must not presume. If I had been presuming anything I would have never tried to make a vulcanised solution, because vulcanised solution ought to be insoluble.

The CHAIRMAN: Do you remember the amount of concentration?

Dr. HELBRONNER: The concentration of the solution was 10 per cent. rubber and a high amount of sulphur.

The CHAIRMAN: I think really you two could settle this a great deal better by yourselves afterwards. We can get very little out of it this way. I hope we can find time to open up this discussion again, but now there is a limit to our time.

The discussion then closed.

The Mass Action of Sulphur in Vulcanisation.

By

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Without doubt, the two theories on vulcanisation have stimulated an enormous amount of experimental work in connection with the truth of vulcanisation. This investigation was undertaken with the idea of arriving at some conclusion as to the tenability of the physical or chemical theory of vulcanisation. It is by no means a finished work, but still many useful ideas can be deduced from the results. The investigation experimentally was very difficult until it was realised that a difference of ·005 inch in the thickness of the calendered sheets of rubber was sufficient to completely spoil the results for any comparative purposes.

The sheets of rubber used were calendered to ·020 inch, and the greatest variation between any two sheets was ·0015 inch. All the rubber used (hard fine Pará) was broken down on the rollers at one time. The respective mixes were then made by taking a portion of this rubber and the requisite amount of sulphur. The time taken to make any mix had to be within 1½ minutes of the average time taken (13 minutes). They were all 5-lb. lots, and were immediately calendered. The sheets were allowed to stand for a fortnight before using, and the combined sulphur was determined on the unvulcanised sheets. This in every case was found to correspond with the amount originally in the Pará. The total sulphur was determined on the unvulcanised sheets in order to know exactly how much sulphur was present, and to prevent, if possible, any mistake occurring.

For the purpose of vulcanisation of the sheets, a long, smooth, tinned iron tube (very thin) was used. This was covered with tin-foil, and the different rubbers were placed in order along the tube and numbered. A distance of 2 cms. separated each sheet. The whole was then covered with tin-foil, and finally tightly bound with wet cloth.

The tube when ready was introduced into a previously warmed vulcanising pan which could be raised to the required conditions within two minutes. After vulcanisation, the sheets were separately rolled on a small pair of experimental rolls. It was observed that for short cures, and particularly when a large amount of sulphur was present, some of the sulphur oozed out to the edges and surface of the rubber. This has quite an important bearing on the later remarks about the results. All the experiments were carried out at 140° C. (284° F.). The temperature was registered by a self-recording thermometer which had previously been tested.

The combined sulphur was determined on each sample by extracting in a Soxhlet for from 20 to 60 hours (depending upon the period of vulcanisation, and then oxidising with fuming nitric acid the carefully dried residue rubber. The total sulphurs were determined, but the method of enclosure in the vulcanising pan practically assured no loss of sulphur.

EXPERIMENTAL RESULTS OBTAINED.

Combined Sulphur.

Period of Vulcanisation.	3%S.	5%S.	10%S.	20%S.	30%S.	40%S.	50%S.
½ hr. @ 140° C.	·36	·44	·63	·59	·55	·51	·48
1 ,, ,, 140° C.	·46	·63	1·07	1·05	·95	·83	·76
1½,, ,, 140° C.	·70	1·02	1·65	1·64	1·47	1·32	1·15
3 ,, ,, 140° C.	1·42	2·06	3·35	4·07	3·58	3·13	2·81
6 ,, ,, 140° C.	—	2·88	6·18	11·33	11·62	10·93	10·22
9 ,, ,, 140° C.	—	—	8·76	17·32	24·10	25·5	25·0

A much different aspect from the result appears when they are all calculated on the basis of 100 of rubber. It is quite apparent, then, that vulcanisation occurs in its simplest form at the commencement of the re-action. Afterwards many factors begin to show their effect. The results are much better grasped by means of graphs, and for that reason the whole series of results were linked up by curves that were made more or less smooth. In consideration of this work, it must always be borne in mind that the general trend of the results only has been obtained ; their exact mapping out will no doubt take place when our methods of estimating the sulphur in rubber are much more accurate than at present.

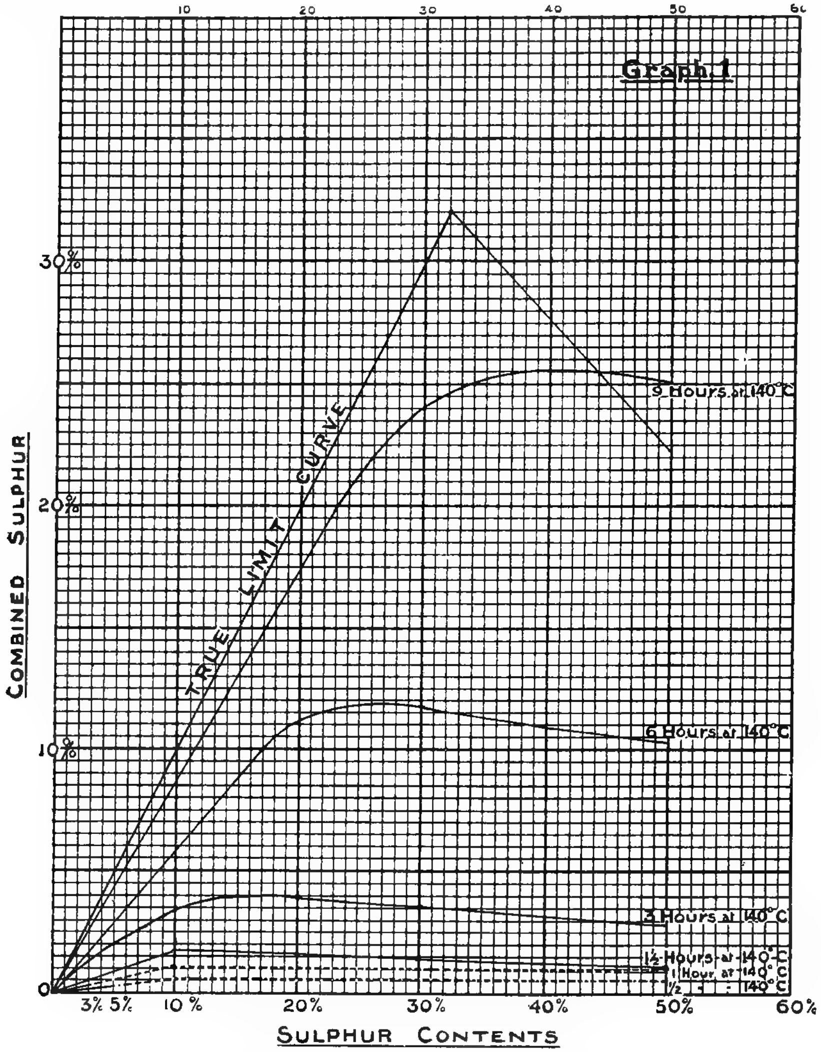
COMBINED SULPHUR.

Calculated per 100 *Pará.*

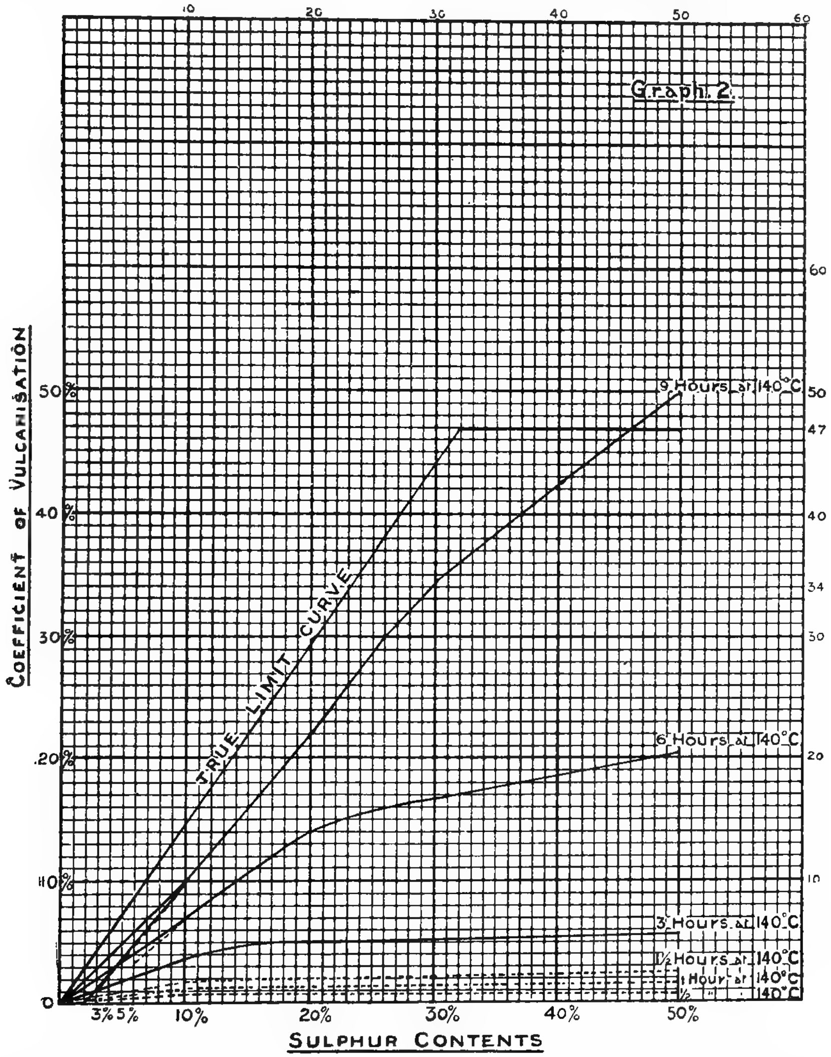
Period of Vulcanisation.	3%S.	5%S.	10%S.	20%S.	30%S.	40%S.	50%S.
½ hr. @ 140° C.	·37	·46	·70	·74	·79	·85	·96
1 ,, ,, 140° C.	·47	·66	1·19	1·31	1·36	1·38	1·52
1½,, ,, 140° C.	·72	1·11	1·84	2·05	2·10	2·20	2·30
3 ,, ,, 140° C.	1·46	2·17	3·72	5·09	5·14	5·22	5·62
6 ,, ,, 140° C.	—	3·03	6·86	14·16	16·66	18·22	20·44
9 ,, ,, 140° C.	—	—	9·73	21·65	34·43	42·5	50·0

If we examine Graph No. 1 a maximum point can be observed on each curve. This maximum point in the curves obtained for a short period of vulcanisation can be most easily explained in the following way.

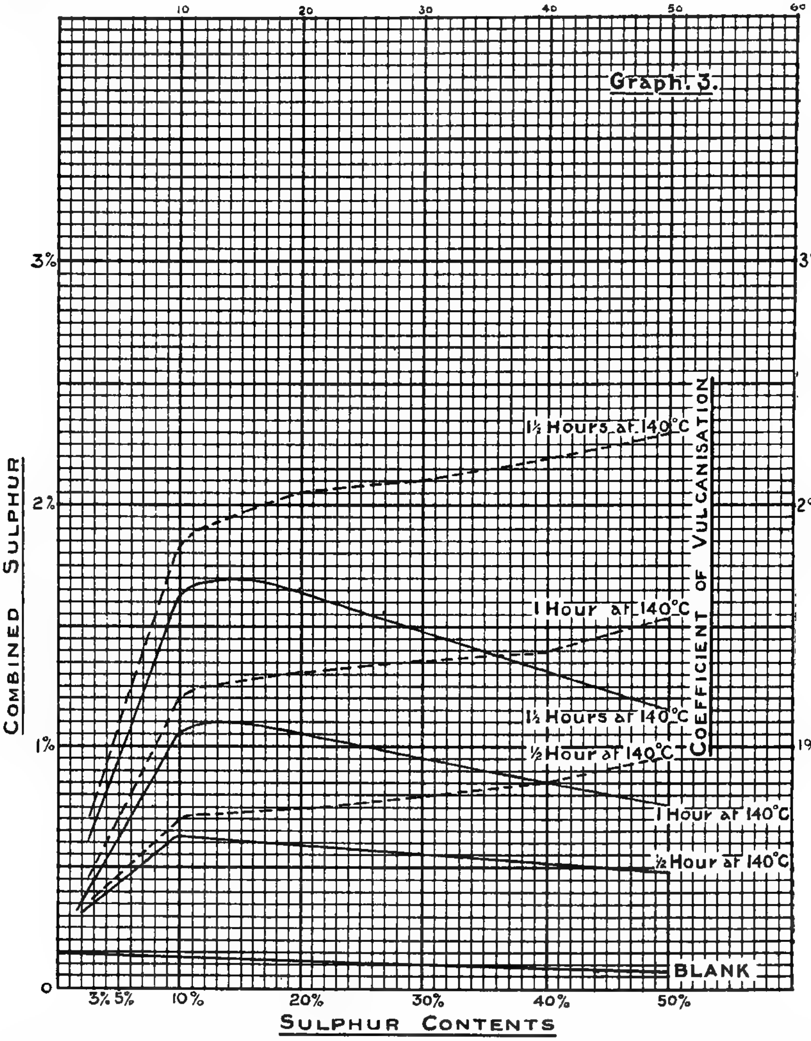
In a previous paper in the Koll Zeit of January, 1914, the author suggested a method for measuring the approximate maximum solubility of sulphur in rubber. The value was obtained by allowing sulphur to migrate into pure rubber from a mix containing about 30%S. or more. It was found that a mix containing 10%S. and 90% Pará was at the commencement of vulcanisation approximately a saturated solution of sulphur in rubber. It would be found by referring to Graph No. 1 that the maximum point on the lowest curve corresponds to the maximum solubility of sulphur in rubber. As the period of vulcanisation increases this maximum point gradually moves to the right. Theoretically this maximum point at infinite time would be at 32%S. combined sulphur and containing no free S., *i.e.*, it would represent pure polyprene di-sulphide. Any other point on this limit curve would either represent polyprene di-sulphide and excess of rubber or polyprene di-sulphide and excess of free sulphur. The author can offer no satisfactory explanation of what this maximum point represents in the intervening curves between the two limits of time except the following obviously patent one: "That this maximum point corresponds to the ratio of sulphur to rubber necessary by which one can obtain the greatest amount of polyprene sulphide at a stated temperature and given period of time."



In Graph No. 2 this maximum point is emphasised by the appearance of a flat portion on the curve. The results in this graph are all represented as the amount of combined sulphur formed from 100 parts of rubber, *i.e.*, the coeff. of vulcanisation. In this case excessive sulphur, *i.e.*, sulphur which is not dissolved in the rubber, has no large effect upon the curves. There seems to be a very slight effect as represented by the slight incline of this hitherto-called flat portion, but it can no doubt be explained by a molecular effect of this sulphur upon the sulphur-rubber phase, or by the greater excess of undissolved sulphur causing the sulphur-rubber phase to keep more constant, and also by forming more easily polyprene polysulphides which would raise the velocity of re-action. This incline of the curve increases with increasing time, and no doubt can better be explained by the joint action of the two latter hypotheses.



A theoretical combined sulphur to correspond to 32% would, on calculating to 100 rubber, be approximately 47. It will be observed that in Graph No. 2 that one value reaches 50%. This sample was extracted for 60 hours, and also in two lots of 30 hours, the last 30 hours only extracting ·4% more free S., which when one extracts ·4 grm. is almost commensurate with the value obtained from a blank. More free sulphur can be extracted by acetone under pressure until this value is below 47.



This work is not quite finished, but this result alone shows that without doubt either poly-sulphides or an insoluble form of sulphur exists in hard rubber.

In Graph 3, the three lower curves on each of the other graphs are repeated with a combined sulphur scale made much larger. From these curves it is apparent that the combined sulphur increases in equal times for an increased concentration of sulphur in rubber. This only holds true until the maximum point on the curve is reached; beyond this maximum point, the rubber is saturated and this observation does not hold, *i.e.*, until the maximum point is reached, the curve obeys the following law:

$$y/m = ac$$

where y = amount formed
m = reacting masses (in this case equalling unity)
a = a constant
c = concentration of S. in rubber.

If, however, the reaction were an adsorption phenomenon it would have the form

$$y/m = ac^{1/n}$$

where n = a new constant and in all known cases lies between 2 and 10.

In the curve obtained $n = 1$ and obviously does not come under this category.

The influence of concentration is very important when one considers the role it plays throughout all kinds of rubber manufacture. The sudden increase in the rise of these curves, if investigated more carefully, would no doubt lead to many important factors and considerations about the efficiency of acetone extraction as to whether in all cases the extracted sulphur represents true combined sulphur, or is some of this sulphur really attached to the true combined sulphur, this forming a poly-sulphide of rubber analogous to $H_2 S_x$ where X is greater than one.

The CHAIRMAN: I must compliment Mr. Skellon on a most excellent paper. He spoke of extracting with acetone under pressure. I should like to ask what pressures were employed, and how the pressures were measured?

Mr. SKELLON: I tried many ways of measuring, but had great difficulty and with no success. The way in which the extraction was carried out was to have a small bottle with a very thick neck, and a piece of ground glass on the top of the bottle. The whole thing was screwed down very tightly and heated up to 140 degrees Centigrade. I have done much work on the acetone extraction, extracting this new free sulphur, as I call it, at 70, 90, 110, 130, and 150 degrees Centigrade. Above 110 degrees Centigrade most of it comes out. If you extract at 70 degrees Centigrade you get it just the same as under normal conditions. I have extracted many samples first by acetone in the ordinary way, and then used this extraction under pressure as a measure of this new free sulphur.

Dr. D. J. THOMPSON: I would like to ask the reader of the paper if he does not think the extra sulphur that comes out is probably due to the breaking down of the vulcanised rubber owing to the increased temperature following his increased pressure. We know that this is the effect if you get a sufficiently high temperature, so that unless he gives the temperatures at which he extracts I do not think we can decide whether it is free sulphur from rubber or the result we get by heating with zylol to about 160 degrees. I would be glad if Mr. Skellon would tell me if in his opinion any more than 10 per cent. of sulphur on the rubber is to be used to cause acceleration. While not having done much theoretical work on those lines, being with one of the fairly large manufacturers in the United States we put in more than this occasionally. According to Mr. Skellon's graphs 10 per cent. on the rubber is just the amount that will go into solution, and after that no acceleration, or very little, takes place.

Mr. SKELLON: Only 10 per cent. at the beginning of the reaction. If you added 50 per cent. of sulphur you would decrease the velocity initially. If you add 10 per cent. of sulphur initially, the velocity at the commencement is at its maximum, but eventually the 50%S mix begins to overtake it, through an increase in its velocity, due to the action of the polysulphides which would then be present.

Dr. THOMPSON: If it is a case of chemical combination, and you put more and more sulphur in, there is a chance that you will not get such an intimate mixture or that you will not get such a contact between the sulphur and the rubber. Further, we all know that it is possible to add certain oils which have a solvent effect on the sulphur, and help considerably in vulcanising. This may be due to the fact that they dissipate the sulphur through the rubber and in that way help in just the same way as the adding of more sulphur up to a certain point brings more sulphur to the surface of the rubber substance.

Mr. SKELLON: On the question as to the breaking down of the rubber under pressure, the crux of the matter is that I repeated this thing six times, and in each case the result was so sudden that 95 per cent. of the new free sulphur came out at the first extraction. I do not say there is not a little breaking down, but the result is not comparable with the amount of sulphur that comes out the first time. With regard to the question of the 10 per cent. of sulphur, if you have 80 per cent. of rubber and 20 per cent. of sulphur, about 9 per cent. of the sulphur is going to affect the rubber, and the other is going to have no effect on the velocity initially. In reply to another point, I may state that I tried different solvents, and no matter which is used the question to consider is the boiling point of the solvent. I tried the whole series of alcohols. If you take an alcohol with a boiling point above 110 you get a result within 0·5 of the free sulphur result. I have taken solvents analogous to benzene, zylene and so on. To get a big result you must take something analogous to ebonite when the new free sulphur is likely to be high. I am only just on the work now, and what I will have to do is to extract about 10 grammes of rubber in order to obtain some measurable value of this new free sulphur, because at the commencement of vulcanisation the polysulphide effect will naturally be low.

Dr. STEVENS: I remember Mr. Skellon's previous paper, but could never quite follow it. I was never clear as to how he proved that sulphur was dissolved and not combined.

Mr. SKELLON: It was extracted by acetone.

Dr. STEVENS: Wholly extracted?

Mr. SKELLON: No. If you have a sheet of pure rubber and place in contact another sheet of rubber containing a large proportion of sulphur in ten minutes at 143 degrees Centigrade you would find 10 per cent. of free sulphur where previously there was none.

The CHAIRMAN: All that was extractable?

Mr. SKELLON: It was practically not combined at all. The free was about 9·6 per cent. and the combined below 1 per cent.

Dr. SLOCUM: Have you got any photo-micrographs of vulcanisation showing you get only globules? Do you get actual globular presence of sulphur, or is it a mere colloid dispersion?

Mr. GIBSON: Dr. Loewen might tell us the results of his experiments on this very point. Before he does so, I would like Mr. Skellon to clear up one point, following on the matter that Dr. Stevens mentioned. He claims that polyprene sulphide is a better absorbent than the pure hydrocarbon. I give you my interpretation, but do not say it is the right one. It rests with Mr. Skellon to show that it is not the interpretation. He vulcanised a sheet, then took another sheet that was unvulcanised, then vulcanised the two and afterwards found there was more combined sulphur and more free sulphur in the sheet first vulcanised. Now I would have suggested that the reason there was more sulphur, combined and free, in the sheet that was first vulcanised would be that it was longer in the process of vulcanisation. The first sheet was vulcanised, I forget the number of times, but for periods of four hours each.

Mr. SKELLON : You have missed the whole point. The sulphur migrated from the unvulcanised sheet into the vulcanised.

Mr. GIBSON : You say the polyprene sulphide is better than the crude rubber.

Mr. SKELLON : Also in that particular case it has a greater total sulphur and more free sulphur. In one sheet there was a certain amount of polyprene sulphide and less rubber, and in the other sheet a less amount of polyprene sulphide and more rubber ; yet each sheet contained the same amount of rubber initially. The sheet with the greater amount of polyprene sulphide had the larger percentage of free sulphur, therefore it follows naturally that sulphur must be more soluble in the polyprene sulphide than in the rubber hydrocarbon itself.

Dr. LOEWEN : Might I call attention to my experiments, which were carried out two years ago, and the results of which were published in the *Gummi Zeitung*. The chief experiment was carried out in this way :—I took a small piece of rubber between the two microscopical object slides and pressed it until it was very thin. Then I brought in sulphur between the two slides, so that it surrounded the whole circumference of the piece of rubber. In the heating I could observe that the sulphur was migrating, or went by diffusion into the rubber, and it was to be observed there when cooling again, first in the form of globules and later in the form of crystals. At the same time it was to be observed that on the outer circumference of the rubber vulcanisation had taken place to such an extent that the light could not get through as well as in the unvulcanised rubber, and in the same zone the sulphur did not contain crystals any more. I think I can say from this that sulphur is more soluble in rubber sulphides than in the rubber itself. This experiment can be carried out very simply, and one does not need a microscope for observing it.

Mr. SKELLON : I may explain that my method of procedure was this. I took rather a large sheet of rubber, placed it on a sheet of tinfoil, and then the top surface was French chalked or rubbed with talc. The under surface of the vulcanised rubber was treated in the same way, the two pieces were placed together, and a layer of tinfoil was placed on the two sheets, the two being enclosed in thin steel plates, and kept in position by tightly bound cloth.

A DELEGATE : If there were any pressure, the total rubber substance itself would flow at a temperature. Rather would it be a flowing of the mass than a migration.

Mr. SKELLON : If this flowing took place you would never separate the two sheets.

The DELEGATE : To a certain extent. How many analyses did you have to ensure uniformity ?

Mr. SKELLON : About eight. There was no difference whatever. In these experiments there was no pressure. A cork was placed in the middle of the two plates to keep them from moving. The sheets would separate, however, at will.

The Delegate: It migrated across the chalk?

Mr. Skellon: Oh, yes. This migration takes place under ordinary circumstances.

Dr. Slocum: In migrating it must be in a very minute dispersion, and it would be interesting to follow that gathering and dispersion of globules. We know that the standard method of telling a good dispersion is by the very quick formation of any substance. That is the way we form our colloid dispersions. Here you get the cooling down in thirty seconds or so; I have not been able to get a slide out quick enough to find the globules. Dr. Loewen, I understand, did not use the microscope for his experiments.

Dr. Loewen: Yes, I had them between the glasses, but in very small pieces. The pieces used were ·1 millimetre.

Dr. Slocum: Did the sulphur migrate in the form of globules or in a transparent form?

Dr. Loewen: In the molecular dispersed form. When cooling, the rubber began to show the globules. Then the globules began to crystallise.

The Estimation of Bitumen in Rubber Mixings.

By
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Chief Chemist,
and
E. ANDERSON, A.I.C.,
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Our attention was first drawn to this question, and to the necessity for a careful investigation into the analytical methods available, by the discovery of bituminous matter by certain of our customers in goods where its presence was next to impossible. At first sight this result seemed surprising, but on reference to the literature on the subject, other observers were found to have had the same experience, and Potts & Britland (J.S.C.I., 1910, p. 1,142) conclusively demonstrate the unreliability of the standard Pyridine method for anything but a qualitative test. It is of interest to quote their conclusion :—

> "These experiments show that even with a carefully prepared blank at hand, the pyridine extraction affords no indication of the amount of bitumen present. Indeed, the non-bituminous sample actually gave a slightly higher extract.
>
> The conclusion to be drawn is that pyridine is usually inadmissible as a solvent for bitumen.
>
> If the bitumen would dissolve out in about half-a-hour or less, some indication of the amount present might be obtained ; in our case, however, the extract remained coloured for a much longer time.
>
> Probably the best, and only safe, way to use hot pyridine is to extract for about 5 minutes in a Weber extractor, as a *qualitative* test only, when bitumens will give an intense brown stain. With a longer time we find the non-bituminous rubbers begin to colour the thimble a light brown."

The method which is generally employed, and which appears in the standard books on rubber analysis is that devised by Weber (Chemistry of India Rubber, p. 243) consisting in treating the acetone-extracted sample with pyridine, as follows :—

> "I connect the extractor with a weighed flask containing about 60 c.c. of pyridine (b.pt. 109-111° C.). This flask I keep in an oil bath the temperature of which is kept between 116° and 120° C. In presence of tar, pitch, asphaltum, the paper at once assumes a more or less pronounced brown colour. I continue extraction until it has assumed its normal tint."

In spite of the adverse criticism which this method has received, it still seems to be generally employed for the want of a better, and it seemed desirable, therefore, to see whether some improvement could be effected, in order to render it reasonably reliable and quantitative. The objections to the method may shortly be stated as follows :—

(1) Objectionable odour of this solvent.
(2) The comparatively high boiling point (115° C.) of the solvent.
(3) The solution of a proportion of the bitumen by the preliminary acetone treatment.

(4) The solution in certain cases of the caoutchouc by the pyridine in appreciable quantities, thus rendering doubtful the value of any positive result.

The natural procedure when devising an analytical method is to consider the nature and properties of the substance to be determined. With this end in view we consulted the voluminous literature dealing with Bitumen, Asphaltum, and Pitch, and we would refer those requiring fuller information on this interesting branch of technical chemistry to an excellent book by S. F. Peckham, entitled "Solid Bitumens." A few notes here, however, would not be out of place.

Bitumen includes a large number of inflammable mineral substances consisting chiefly of hydrocarbons. Certain varieties contain, besides carbon and hydrogen, compounds of nitrogen, sulphur or oxygen. Occasionally iron and alumina are found, in combination with organic matter, as essential constituents. These bodies may have the solid or the fluid form, and include all natural inflammable gases, the well-known liquid petroleum, the peculiar, dark-coloured, viscous substance known as mineral tar or maltha, and lastly, the solids, asphalt, ozokerite, and mineral rubber. The term also embraces many products of the arts, the best known of which are coal tar and the pitch derived from it. Others are formed in the destructive distillation of woods, bones, and bituminous shales, and these vary to a large extent with their origin and method of preparation. S. F. Peckham divides bituminous substances into three classes, namely :—

(1) Bitumens,
(2) Pyro-bitumens, and
(3) Artificial or factitious bitumens.

The first class embraces those natural bodies to which reference has already been made. They are all more or less soluble in various neutral liquids, but particularly in carbon disulphide and in chloroform. The pyro-bitumens forming the second class are substances which yield on heating products approximating in general properties to natural bitumens. In the third class are included all substances resembling natural bitumens, obtained from pyro-bitumens and other crude materials, usually by distillation, but sometimes by chemical processes.

In our search for information regarding bituminous substances, we have found statements on the subject most contradictory. The reason for this is that there exists a large amount of confusion and overlapping, caused by the fact that the terms "bitumen," "pitch," "asphaltum" and other names applied to substances of this type have no standard definition attached to them. At the Eighth International Congress of Applied Chemistry, held in New York in the autumn of 1912, a proposed classification and list of definitions was submitted by Herbert Abraham. His suggestions have been published by the American Chemical Society (J. Ind. Eng. Chem., 1913. Vol. 5, p. 11), and are based principally on origin and physical properties. From the point of view of the chemist, it would be much more satisfactory if chemical composition were adopted as the basis of nomenclature, but comparatively little accurate information on that point is available, so that such a scheme has never been formulated.

Deposits of bitumen and bituminous rocks are found in many parts of the world. The chief of these occur in North and Central America, in the countries bordering on the Mediterranean Sea, and in the upper valley of the Rhone. It is generally agreed that, although bitumens differ very widely according to the localities in which they are found, all the various forms have been derived from one common source. This general statement includes every variety, from natural combustible gas, through naphtha, petroleum and maltha to solid asphaltum. What the original source of the bitumen has been is still a debatable question. Moissan's work on the formation of carbides with the electric furnace, and his production of hydrocarbons by the action of water on the carbides, has led to the view that petroleum and other natural bituminous bodies have been formed from inorganic substances, in a similar manner. Other theorists assume a change in organic matter—either vegetable or animal or both—under the influence of pressure and heat. This view is supported by the occurrence of sulphur, nitrogen, and oxygen as invariable constituents of certain varieties of bitumen.

Those bitumens which are of interest to rubber manufacturers are either of the natural asphalt type, or are derived from petroleum by distillation of the more volatile portions, leaving behind the pitch-like residue. In general, it is somewhat difficult to distinguish between a natural asphalt and a residual pitch. Methods for the analysis of bituminous substances have been drawn up only on lines which are decidedly empirical and, as such, are in many ways inconclusive and unsatisfactory. Extraction with different solvents, either directly or in succession, has been suggested as a means of analysing these bodies. But for the purposes which we have in view it is of doubtful value, except as a method for checking the regularity of supplies. The standard method used in coal analysis for the determination of *fixed carbon, volatile matter* and *ash* is also recommended for comparing a new supply with a standard sample. No one of these tests is, however, conclusive; for bitumens giving almost identical results analytically have been found in some instances to behave very differently when an attempt has been made to incorporate them in a rubber mixing. After dealing with many samples it has been decided that the only conclusive test is the behaviour of the sample under factory conditions. The outstanding points of interest to be deduced from our search into the publications on the subject are as follow :—

(1) The close relationship between Bitumens and Paraffins, which would therefore seem to render the separation of a mixture of Vaseline, Heavy Hydrocarbon Oil and Bitumen impossible.
(2) The fact that this class of substance seems to be in general entirely soluble in carbon disulphide or chloroform.
(3) The indifference of these substances to chemical reagents will depend largely on whether they consist of saturated or unsaturated hydrocarbons, and this varies with their source.

It immediately appeared to us remarkable that pyridine extraction should ever have been suggested as a method of estimation, and in spite of a very careful search no reference to its employment as a solvent for bitumen could be found in the general literature, with the exception of an article by B. Nickels on " Pitch " in Thorpe's Dictionary of Chemistry, 1905, Vol. iii., p. 251. The residue left on the distillation of Dippel's or Bone Oil is here stated to be entirely soluble in pyridine ; possibly Weber was working on this class of pitch and was therefore led to select this somewhat unusual solvent.

It remained for us to consider the types of Bitumen employed in the rubber industry, and the ingredients with which it would be associated in the finished article. As a result of the examination of numerous samples submitted to the laboratory we incline to the opinion that the products in general use are prepared by a distillation process. It is, of course, exceedingly difficult to make any definite statement on the subject, and our opinion is based on the fact that the mineral residue left on ignition seldom exceeds 0·25%. For the purpose of this investigation we decided to employ a Mineral Rubber—widely advertised in the rubber trade papers, and for the information of other investigators we append the analytical figures.

Volatile matter	86·18%
Fixed carbon	13·68%
Ash	0·15%
Solubility in CS_2	100·00%
Sulphur	2·93%

The first step in the investigation was to ascertain whether the use of freshly distilled carbon disulphide would represent any improvement on pyridine and quantitatively remove the bitumen left after acetone extraction without affecting the rubber. From the point of view of laboratory comfort and procedure carbon disulphide is the more satisfactory solvent. Its lower boiling point renders extraction easier to control and though not a pleasant smelling liquid it does not possess the objectionable odour of pyridine. Blank experiments were therefore carried out on samples free from any bituminous ingredients made up as follows :—

A. Pure.		B. Compounded.		C. Ebonite.	
Plantation Sheet	95 0	Plantation Sheet	30 0	Plantation Sheet	65 0
Sulphur ..	5 0	Sulphur ..	5 0	Sulphur ..	35 0
		Zinc Oxide ..	55 0		
	100 0	LampBlack ..	5 0		100 0
		Litharge ..	5 0		
			100 0		

These were extracted in a finely divided condition with acetone for six hours, and then subjected to the bitumen solvents for periods of one and two hours in a reflux extractor. The solvent was then evaporated off and the residue weighed in the usual manner. This was then repeatedly extracted with cold CS_2 in the manner recommended by Caspari (India Rubber Laboratory Practice, p. 123), and the loss determined.

	A.	B.	C.
Acetone Extract	3·31	4·96	5·52
CS_2 Extract, 1 hour (a)	4·60	6·22	5·04
do. 2 hours (b)	6·74	7·46	5·83
do. soluble in cold CS_2 (b)	1·90	1·41	0·97
Pyridine Extract, 1 hour (a)	6·84	3·61	3·03
do. do. 2 hours (b)	13·71	5·80	3·46
do. soluble in cold CS_2 (b)	3·10	1·64	1·76

It is at once evident from these figures that whichever solvent be employed great caution is necessary in interpreting the results. Caspari states "Carbon disulphide will dissolve out no rubber unless the material be undercured." This statement is not borne out by our results, as both samples B and C were undoubtedly satisfactorily vulcanised.

The action of solvents on bitumen itself was then examined.

Solvent.	Method.	Removed %.	Remarks.
Pyridine	Extraction in paper thimble	77·47	Slowly, extraction takes 5 hours.
Carbon disulphide	until extract no longer	100·00	Rapidly, complete in 1 hour.
Acetone	coloured.	15·50	Very slow, 10 hours taken.
Alcohol		11·96	do. do.

Owing to the samples melting in the thimble and exposing a very limited surface it was thought probable that the figures for alcohol and acetone did not represent the true values. A further acetone extraction was, therefore, carried out using a Gooch crucible, filled with sand above the asbestos. The bitumen was mixed as intimately as possible with the upper layer of sand in order to expose a larger surface (Peckham, "Solid Bitumens," p. 151). After 5 hours the extraction was found to be practically complete, 53·81% being removed.

It will be interesting in this connection to quote the figures given by Caspari for the solubility of the bitumen in a mixing on successive treatments with acetone and carbon disulphide.

	A.	B.	C.
Acetone soluble	58	70	76
Carbon disulphide soluble	17	14	14
Insoluble..	25	16	10
	100	100	100

A.	Para 100,	Sulphur 10,	Bitumen	50	(31·2%)
B.	„ „	„ „	„	20	(15·4%)
C.	„ „	„ „	„	5	(4·35%)

On two samples of soft cured rubber containing 10% of bitumen we ourselves obtained the following results :—

	Acetone.	Carbon disulphide.	Insoluble.
A... ..	46·7	45·0	8·3
B... ..	49·7	47·0	3·3

and to supplement these figures a determination was carried out on a sample of ebonite of the following composition :—

H.F. Para 55·25, Sulphur 29·75, Bitumen 15·00.

Acetone.	Carbon disulphide.	Insoluble.
37·94	18·20	43·86

the analytical figures being :

Acetone extract	11·40%
Resins separately determined	2·48%
Alcoholic Potash extract	1·24%
Pyridine extract, 1 hour (a)	5·26%
do. do. 2 hours (b)	5·62%
do. do. soluble in cold CS_2 (b)	4·30%
CS_2 Extract, 2 hours	2·73%
Free Sulphur	3·23%

As a result of this work it is now possible to take a survey of the position in which this estimation stands, and the following points seem to merit attention.

(*a*) If Bitumen is present in a rubber sample, about 50% will appear in the acetone extract.

(*b*) The solubility of that remaining after acetone treatment in pyridine or carbon disulphide will depend on the degree of vulcanisation (Caspari, p. 54).

(*c*) For the reasons above-mentioned neither pyridine nor carbon disulphide extraction can furnish a quantitative estimate of the amount of Bitumen present.

(*d*) The solubility of non-bituminous matter renders the greatest caution necessary when employing the method as a qualitative test for Bitumen.

These facts require to be considered from two points of view, that of the manufacturer and that of the customer.

As regards the purchase of rubber goods, the position is quite satisfactory since any sophistication with bitumen would at once be indicated on analysis by a high percentage of organic matter soluble in acetone. The manufacturer and works chemist are sometimes called on to assess samples of unknown composition, and if Bitumen is present some information will be required regarding its quantity ; they evidently will derive little assistance from the methods which we have been considering. No deduction can be made from the acetone extract, since, in addition to free sulphur and resins this may contain mineral oils and paraffin wax. Moreover, the percentage soluble in acetone will probably vary with the type of Bitumen employed (Peckham "Solid Bitumens," p. 189). The pyridine and carbon disulphide extracts have already been shown to be valueless as a qualitative estimate.

It occurred to us that some information might be obtained by the method employed for the estimation of Lamp Black in mixings, which depends on the solution of the rubber by means of Nitric Acid. A few experiments were therefore made to see whether this held out any promise of success. The effect of Nitric Acid on the probable ingredients of a mixing was first considered, and the following were tested : Bitumen, Pontianak, White and Brown Substitute, and Vegetable Oil. It had been found when devising the Lamp Black estimation some years ago that complete solution of the rubber could be effected in 15 minutes at 100° C. with Nitric Acid (S.G. 1·355 at 19·1° C. = 57·57% HNO_3). The action of acid of this strength was therefore tried, and gave the following results :

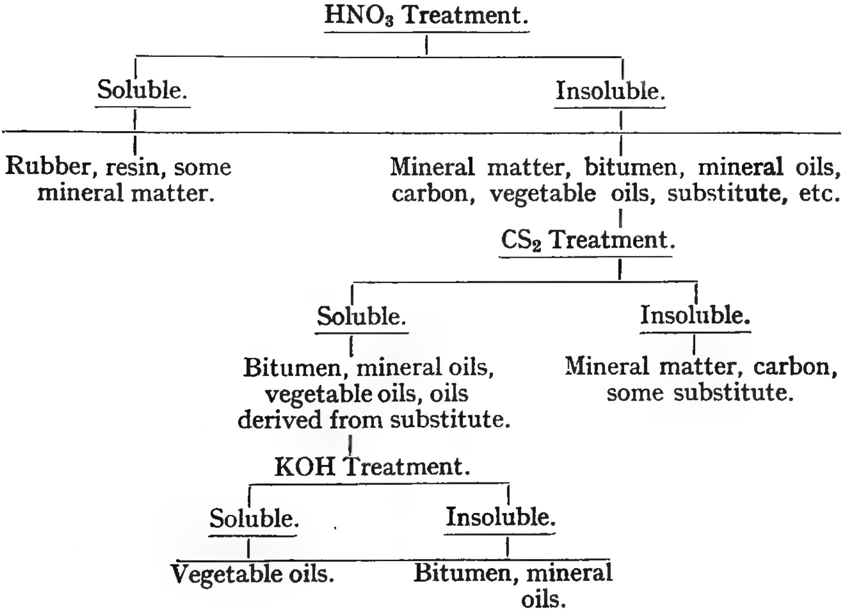
Pontianak Resin ..	Some action, but no solution.
Rape Oil	Little action.
White Substitute ..	Vigorous action with production of oily layer.
Brown Substitute ..	Ditto.
Bitumen	No apparent action.

It was therefore decided to apply the treatment to a mixing containing a known amount of bitumen, and the following was selected :—

Plantation Sheet	65 0
Mineral Rubber	10 0
French Chalk	6 0
Sulphur	5 0
Whiting	10 0
Litharge	4 0
	100 0

The method employed was as follows :—About 2 grams of the sample was weighed out into a flask and treated with 30 c.c. nitric acid for 20 minutes on a steam bath. The liquid was filtered through a Gooch crucible filled with sand, the residue washed, first with nitric acid, and then with water, and finally dried. The crucible was then extracted with carbon disulphide and the extracted matter treated after evaporation of the solvent with 10 c.c. 6% Alcoholic Potash, and heated for a few minutes. After dilution with 40 c.c. water the liquid was filtered and bitumen extracted from the insoluble residue by a further treatment with carbon disulphide.

It was hoped that a separation would be effected according to the following scheme.


HNO_3 Treatment.
Soluble.
Insoluble.
Rubber, resin, some mineral matter.
Mineral matter, bitumen, mineral oils, carbon, vegetable oils, substitute, etc.
CS_2 Treatment.
Soluble.
Insoluble.
Bitumen, mineral oils, vegetable oils, oils derived from substitute.
Mineral matter, carbon, some substitute.
KOH Treatment.
Soluble.
Insoluble.
Vegetable oils.
Bitumen, mineral oils.

Satisfactory figures, however, were not obtained. The sample containing 10% mineral rubber gave by this method a result of 4·2%, while in a similar mixing containing in addition a small proportion of white substitute 1·93 was the figure obtained for the bitumen.

It would appear that the preliminary treatment with nitric acid had rendered a portion of the bitumen insoluble in the solvents, but whether this fully accounts for the discrepancy, we are at present unable to say. This point is being further investigated in view of the fact that it would render uncertain the determination of Lamp Black by this method in any instance where bitumen is present.

We must, therefore, conclude that no satisfactory method exists at the present time for the estimation of Bitumen in Rubber Mixings, and that further progress must not be looked for until the chemistry of the Bitumens has been more fully investigated.

The CHAIRMAN: This is the most interesting paper on this subject that has ever been presented. Although the results are not as conclusive as one might have hoped, and still leave open the vexed question of a satisfactory method for the estimation of Bitumen, I think it is possible that the discussion may bring out some valuable suggestions on this subject.

Dr. ESCH: Would Mr. Porritt be kind enough to let us know what kind of Bitumen has been tried since there are so many different varieties?

Mr. PORRITT: It is difficult to arrive at a definite conclusion regarding the origin of samples of Bitumen. The work was carried out on a type largely used in the rubber trade originating from the United States and which is supposed to be of natural origin. If such is the case, it must have been subjected to very careful purification in order to have reduced the ash to less than 0·25 per cent.

Dr. PICKLES: I should like to ask Mr. Porritt if he has noticed a point which has been put forward elsewhere: that some of the Bitumen during vulcanisation passes from the soluble to an insoluble, form, behaving in this way very much as the rubber does?

Mr. PORRITT: This is certainly the case, and is particularly well marked in the case of Vulcanite, when nearly half the Bitumen is rendered insoluble. I have no information, however, as to whether any combination takes place with the Sulphur, or as to whether Bitumens vary in this respect according to the proportion of unsaturated hydrocarbons present.

Dr. ESCH: That is a most interesting point. In America they state that nearly all this mineral became insoluble in a rubber mixing after vulcanisation.

Dr. SLOCUM: I have private information that the Standard Oil Co. have in use a refining method for the Californian Petroleum, employing liquid SO_2. This solvent might prove to be of service.

Dr. ESCH: My partner is now working on a method making use of this liquid as a solvent.

Dr. SLOCUM: What results have you had?

Dr. ESCH: I cannot bring them before you; the work is not yet finished.

Dr. ARNDT: Every Bitumen contains some Sulphur, consequently it will be impossible to obtain the vulcanisation co-efficient for a rubber mixing containing it as an ingredient.

Mr. BARBARY: I have carried out numerous experiments on the estimation of Bitumen in unvulcanised material, and have employed every solvent I could think of from CS_2 to turpentine. I noticed an interesting point in connection with some of our mixings containing about 2 per cent. of paraffin wax in addition to Bitumen. In such cases both the Acetone and CS_2 extracts are increased considerably more than would be accounted for by the mere 2 per cent. I should like to know whether Mr. Porritt has had any experience with unvulcanised materials, and whether he has employed Trinidad Bitumen for any of his experiments.

Mr. PORRITT: All our work has been carried out on vulcanised samples. So far as we know we have not had any experience of Trinidad Bitumen, but as I have stated, we are usually without information regarding the geographical source of our supplies, and analytical figures do not supply much information.

On the Use of Nitric Acid as a Solvent for Compounded and Vulcanised Rubbers.

BY

HENRY WILLIAMS JONES.

The process described, I have found most convenient as a means of separating carbon black, and as it is also an indicator of the presence of the so-called "hydrocarbons," it may be useful in the hands of other chemists. If not (in the case of mixtures of free carbons with the hydrocarbons alluded to), entirely quantitative, it is at least a good supplementary test to other and special methods.

Referring to the so-called "hydrocarbons" there will always remain the initial difficulty appertaining to their composition. In other words, these variable compounds may contain free carbon as a constituent part. But, over and above that, we have the fact that there is always a portion soluble in acetone, varying in amount from 25 to 75 per cent., so that if we operate upon an acetone-extracted rubber, we are only then dealing with what may be designated as " hydrocarbon residue."

With the nitric acid treatment and under the heat employed, this hydrocarbon residue invariably attaches itself to the porcelain dish near the surface of the liquid, whilst the free carbon readily sinks to the bottom as a black powder.

In the case of lamp black and some other carbons, there is a certain amount of oily and resinous material present, and this being removed by the acetone extraction, will have to be discounted in any report made.

I have been accustomed to operate upon 1 to 2 grammes in a fairly capacious porcelain dish, with 40 cc. nitric acid (1.42), the dish being covered with a watch glass and heated on the water bath. When solution is completed, this dish is removed from the source of heat and allowed to remain at rest. The entire cooled material is collected on asbestos, packed in an ordinary funnel or in a Gooch crucible. The moist and insoluble material is washed with cold nitric acid to remove the mother-liquid, then with water to clear the residue from acid and soluble metallic salts. When lead is present, this washing should be followed with a solution of ammonium acetate to safeguard against the presence of any possible sulphate of lead, and this again removed by washing with water.

The insoluble residue is air-dried at ordinary temperatures or in vacuo over sulphuric acid. When required quickly, the residue may be transferred to a tared porcelain crucible and dried in the air bath or in the water oven. A final washing with chloroform is resorted to, followed by ether, acetone and alcohol, to remove any possible resinous impurities. The weighed and perfectly dry material is lastly ignited, and the difference due to the carbonaceous constituents thereby obtained. This examination generally made on an acetone extracted sample, may be performed on a direct sample, and in this case, any wax present will be distinctly visible as a film upon the surface. It is generally so clean and definite, in such a case, that the chloroform solution may be collected and used as a check on the wax obtained by some other method. For the same purpose, an acetone extract may be directly treated by this nitric acid method with the special object of obtaining wax in a separated form.

A Method of Estimating Small Amounts of CO_2 in Presence of Sulphides.

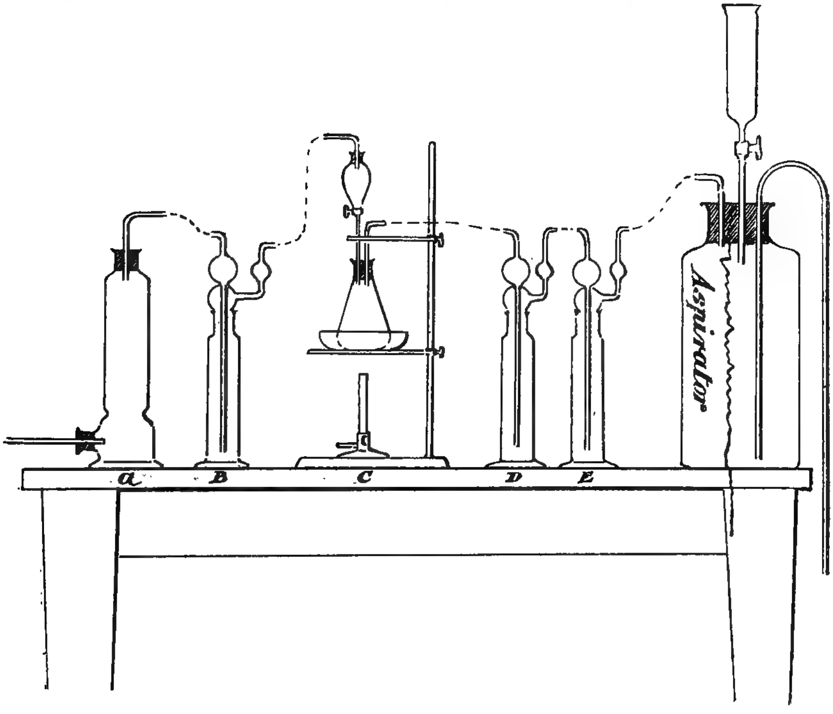
By

HENRY WILLIAMS JONES.

In cases where the amount of CO_2 is small and sulphides are also present in conjunction with carbonates, I have employed with advantage an arrangement readily set up from the usual stock apparatus of a laboratory, and which is figured in the diagram. I commenced experiments with a solution of barium hydroxide in the collecting cylinders, and cupric sulphate in the decomposing flask, but finally used a special solution, based on one originally employed by Fresenius, the modified formula of which I give below.

With barium hydroxide and working volumetrically, the same good results were not obtained as when a precipitated barium carbonate was weighed as sulphate, and this is obvious when we consider the relative weights: 44 parts of CO_2 becoming 233 parts as equivalent weights when taken as $BaSO_4$.

Schrotter's apparatus and similar forms—where the loss of weight is taken—were found to be useless in many cases, as the amount of CO_2 to be estimated was frequently; in amount—about equal to the experimental error.



The appended diagram shows in the marked parts :—

A. Soda lime in cylinder.

B. A trap containing some of the special barium reagent employed in the other cylinders to collect the CO_2; but here placed as a test for the purity of the air being drawn through by the aspirator (reduced in size).

C. Decomposing flask in which the separated insoluble portion of the rubber is placed, and treated with 10 cc. of water, and 10 cc. hydrochloric acid.

D and E. Collecting flasks for the evolved CO_2 and containing respectively 30 cc. and 15 cc. of the reagent. In cases where there is a considerable amount of carbonates present, I employ an extra cylinder, and a further amount of the solution.

Special Solution.

This was devised with an excess of ammonia to arrest any free hydrochloric acid. Sulphides are held in solution, so that it is not necessary to use copper or cadmium salts in the decomposing flask.

Barium chloride 30 grammes in 180 cc. of water.
Liquid Ammonia (880) 36 cc.
Water sufficient to measure 300 cc.

This solution is heated up in the water bath, and allowed to cool and deposit.

On heating the solution a precipitate of barium carbonate will usually form from the contained CO_2, as a dissolved impurity or derived from air-exposure. It is best to filter off the clear fluid whilst still warm, without delay, exposing to the air as little as possible. The solution may then be kept ready for use and decanted off from any slight precipitate which falls. In use, the mixture with the free CO_2 in the cylinders may remain clear for a short time, carbamate of ammonia being formed.* As the carbamate may not have been entirely converted to carbonate of barium by the heat of reaction, the fluid must be heated in order to precipitate all the CO_2. This necessitates removal to a flask provided with an india-rubber tube valve, or a short length of glass tubing drawn out to a fine point. It is best to allow a temperature of 98° to be reached. In practice, and if done rapidly, nothing beyond a negligible trace of CO_2 will be absorbed from the air.

The rapidly collected and washed carbonate is dissolved with the aid of hydrochloric acid, and the estimation as barium sulphate made in the usual manner.

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* $NH_4\,NH_2\,CO_2 + H_2O = (NH_4)_2\,CO_3$.

Experiments on the Determination of Mineral Matter in Rubber Mixings.

By

B. D. Porritt, B.Sc. (Lond.), F.I.C.,
Chief Chemist,

AND

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THE CHAIRMAN : First of all this morning we have a very interesting paper by Messrs. B. D. Porritt and R. Wheatley, of the North British Rubber Company, on experiments they have made in the direct determination of mineral matter in rubber mixings. All of us who have had anything to do with that work will know that there is a great deal of difficulty in connection with it, and any light that can be thrown on the subject will be for the benefit of everybody.

MR. B. D. PORRITT : I feel a diffidence in bringing this paper forward after the brilliant series already presented to the Congress, and this is particularly the case when the information that one has to give is not of a very great amount of practical assistance.

The accurate determination of mineral matter in rubber samples is a problem which often confronts the analyst, being frequently a matter of extreme difficulty, and, in certain cases, almost impossible. The explanation of this difficulty lies in the physical and chemical characteristics of vulcanised caoutchouc and the fact that any treatment to eliminate the organic matter must be of so drastic a nature as to involve possible chemical alteration in the mineral constituents employed.

The determination by ignition as commonly employed in works control is unsatisfactory in the presence of lamp black or other forms of carbon, carbonates, many sulphides, such as those of antimony, mercury and arsenic, etc., and such constituents must be estimated by special and tedious methods. In particular, we might refer to the method for the estimation of antimony sulphide (W. Schmitz, "India Rubber Journal," 9th March, 1912). In the other instances, oxidation with nitric acid in a sealed tube—Carius method—will yield good results. The problem presented when the presence of calcium or magnesium oxide is suspected in a calcium or magnesium carbonate mixing is far more difficult, and it is with this that the present paper is chiefly concerned.

In the absence of organic matter the proportions of a mixture of slaked lime and calcium carbonate or magnesium oxide and carbonate can be readily determined. (Lunge, " Technical Methods of Chemical Analysis," Vol. I., Part I., p. 483.) But when rubber is present and the oxide is in relatively small amount compared with the carbonate the problem is exceedingly difficult. This is particularly unfortunate, as these two oxides are active accelerators of vulcanisation, and their exact determination is often a matter of considerable importance. The problem, therefore, consists in the removal of the organic matter without altering the composition of the mineral constituents, and it will be necessary to consider the available methods and the behaviour of the constituents under the particular experimental condition.

It will be convenient before considering these methods to review the properties of the inorganic substances involved.

The lime is used in the form of Hydroxide $Ca(OH)_2$, and a typical analysis is as follows :—

$Ca(OH)_2$	95·0
$CaCO_3$	3·0
Impurity	2·0
Moisture	nil
	100·0

Only a small percentage of this ingredient is ordinarily employed in mixings.

Calcium carbonate or whiting will normally contain about 95% $CaCO_3$, the remainder consisting of alumina and oxide of iron ; this is one of the most commonly employed " filling agents."

Magnesium oxide, calcined magnesia or magnesia usta will be found generally chemically pure, but in the same way as lime it may on exposure to air take up carbon dioxide with the formation of magnesium carbonate.

Basic magnesium carbonate, magnesia alba or magnesia appears to be one of the purest compounding materials—on analysis it gives figures in fair agreement with the formula $Mg(OH)_2, 3MgCO_3, 3H_2O$ which requires $MgO = 44{\cdot}16\%$.

On heating calcium and magnesium carbonate the following reactions will take place :—

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$Mg(OH)_2, 3MgCO_3, 3H_2O \longrightarrow 4H_2O + 4MgO + 3CO_2.$$

It was, therefore, immediately evident that the ignition method was useless for the removal of organic matter, and it remained to consider the various methods of solution suggested by the original nitro-benzene method of Weber depending on the treatment of the vulcanised rubber by an organic solvent at a high temperature.

The following table shows the solvents suggested by investigators at various times.

SOLVENTS SUGGESTED FOR THE SOLUTION OF VULCANISED RUBBER.

Substance.	Investigator.	Reference.	Details.
Nitro-benzene $C_6H_5NO_2$	Weber and others	—	—
α Nitro Naphthol $C_{10}OH_7NO_2$	Weber	Chemistry of India Rubber p. 248	Heated to 170°–180° C. dilute with benzene and filter.
Xylene $C_6H_4(CH_3)_2$ B.P. 140° C.	Marckwald & Frank	Gummi Zeitung, 1908, xxii., p. 1344.	Heating in autoclave at 15 atmospheres for 3-4 hrs., dilute with ether & filter.
Petroleum B.P. 300° C.	(Henriques) Axelrod	Gummi Zeitung, 1907, xxi., p. 1229.	—
Paraffin B.P. 230°–260° C.	(Henriques) Hinrichsen and collaborators.	Chem. Zeit., 1909, xxxiii., pp. 735, 756.	Dissolve by heating at 180°–200° C., and dilute with benzene and centrifuge.
Phenetole $C_6H_5OC_2H_5$ B.P. 172° C.	Hinrichsen & Marcusson	Chem.Zeit, 1910, xxxiv., p. 839.	Solution at boiling point.
Ditto	Beadle & Stevens	Analyst, 1912, xxxvii., p. 13.	For impurities in raw rubber heating at 140° C.
Anisol $C_6H_5O\,CH_3$ B.P. 152° C.	Hinrichsen & Marcusson.	Chem.Zeit, 1910, xxxiv., p. 839.	Solution at boiling point for 2 hours.
Cumene $C_6H_5.CH(CH_3)_2$	Pontio	Bull. Soc. Chim. 1909, p. 428	—
—	P. Goldberg	Chem.Zeit, 1913, xxxvii., p. 85-86	Distillation in a current of Nitrogen at low temperature.

As will be seen, all these methods require a temperature involving the possibility of the following reactions :—

(A) Conversion of Carbonate to Oxide,

$$CaCO_3 \longrightarrow CaO + CO_2$$
$$MgCO_3 \longrightarrow MgO + CO_2$$

(B) Interaction of Lime with Magnesium Carbonate,

$$MgCO_3 + Ca(OH)_2 \longrightarrow MgO + CaCO_3 + H_2O.$$

In considering the system CaO, $CaCO_3$ CO_2, it is well known that there is a definite pressure of carbon dioxide for each particular temperature and if the pressure is altered the proportions of the other constituents will alter until the equilibrium pressure is attained. As the dissociation pressure of $CaCO_3$ at the experimental temperatures is exceedingly small there is practically no danger of loss due to the reaction,

$$CaCO_3 \longrightarrow CO_2 + CaO.$$

In the case of magnesium carbonate, the same considerations apply, only, in this instance, the vapour pressure of the CO_2 is much higher and, therefore, the possibility of loss correspondingly greater.

An investigation into the dissociation of the carbonates of the alkaline earths and magnesium carbonate (Otto Brill, Zeit. Anorg. Chem., 1905, xlv., pp. 275–292) has shewn that the temperature at which the pressure of carbon dioxide becomes equal to one atmosphere is 825° C. for calcium carbonate, whereas for a series of basic magnesium carbonates the corresponding temperatures range from 265° C. to 510° C. As this paper deals with the equilibria conditions and was not carried out with commercial magnesium carbonate, simple experiments were made to ascertain the stability of this product under the conditions obtaining in the analytical methods proposed (see Table).

The test was carried out by mixing the carbonate with nitro-benzene in a small tube and heating in a nitro-benzene bath for 4–5 hours at 170°–180° C. The percentage of oxide was determined before and after this treatment, and gave the following figures :—

Before	44·36%
After	45·39%

Phenetole 150°–160° C. was subsequently tried with similar results.

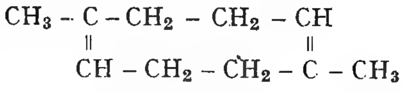
It would, therefore, appear that the danger of conversion of the carbonates to oxides is not a serious one, owing to the solvent hindering the escape of CO_2 and thus tending to maintain equilibrium.

As regards the condition of a mixing originally containing magnesium carbonate and lime, from consideration of the previous remarks on the equilibrium between magnesium carbonate and calcium hydroxide, it is almost certain that a large proportion of, if not all, the lime would be converted into carbonate during vulcanisation and analysis. The practical application of this would seem to be that in a magnesium carbonate mixing the employment of lime as an accelerator is tantamount to employing the equivalent amount of magnesium oxide.

The objections, therefore, to the above methods must be founded merely on manipulative difficulties which have been found to be considerable.

At this time work was proceeding in our laboratories on the effect of ozone on vulcanised rubber, and it seemed possible that this reaction might be applied to this problem.

The effect of ozone on raw caoutchouc has been thoroughly investigated in a series of papers by Harries (Ber., 1905, xxxviii., p. 1195, seq). As a result of this work he proposed the following as the probable formula of caoutchouc :



$$\begin{array}{l} CH_3 - C - CH_2 - CH_2 - CH \\ \qquad\quad \| \qquad\qquad\qquad\quad\;\; \| \\ \qquad\;\; CH - CH_2 - CH_2 - C - CH_3 \end{array}$$

or 1.5 di-methyl cyclo-octadiene.

and found that according to the concentration of the ozone, one or other of the following substances is formed:

$C_{10}H_{16}O_6$	$C_{10}H_{16}O_8$
Ozonide	dioxyozonide.

These products, particularly the dioxyozonide, are soluble in certain organic solvents and may be recovered without alteration.

No work appears to have been carried out on the action of ozone on vulcanised rubber, though its marked destructive effect on rubber tubing is well known.

In order that this might constitute a quantitative analytical method for the separation of mineral matter, the following two conditions had to be fulfilled:

(1) The mineral matter must remain unchanged.
(2) The organic matter must become completely soluble.

Preliminary experiments showed that the success of the reaction with ozone largely depended upon the use of oxygen and an apparatus capable of yielding a gas rich in ozone. The apparatus used was substantially the same as described by Harries in his paper (Annalen, cccxliii., 1905, p. 375) on the action of ozone on organic compounds. As alternating current was not available, a small 0.12 kw. converter was used, converting 220 volt direct-current to 125 volt alternating current, frequency 50. This was then transformed to 8,000 volts pressure and supplied to the terminals of the ozoniser.

Passing in oxygen at the rate of 1 litre in 5 minutes, the amount of ozone in the issuing gas was 5% to 6% by weight estimated by means of acidulated potassium iodide solution.

Before considering the effect of ozone on vulcanised rubber, it was necessary to ascertain whether any change took place in the common inorganic materials employed as filling ingredients when exposed to its action. With this end in view the following samples were exposed to ozone for 1½ to 2 hours and any alteration in weight or reaction noted. The results were as follows:—

Unattacked.—ZnO, French Chalk, $BaSO_2$, $CaCO_3$, $MgCO_3$, MgO, $Ca(OH)_2$.
Attacked.—Lithopone, ZnS, Sb_2S_5, S.

This points to the fact that alteration will take place in any instance in which a higher state of oxidation is possible, which debars the method from general application, but, since the constituents particularly under consideration remained unaltered, the work was continued.

The rubber was finely rasped on a steel buffing wheel and treated with acetone in a Schidrowitz extractor for 6 hours to remove resins and free sulphur.

The first sample employed was prepared from the following mixing:

Zinc Oxide	50
Sulphur	2½
Plantation Sheet	47½
	100

This composition was chosen since the removal of organic matter could be readily followed by means of a simple ash determination. Unfortunately, it was impossible to carry out the ozone treatment in solution, as was done by Harries, owing to the insolubility of vulcanised rubber in all solvents. A weighed quantity, therefore, contained in a wide-mouthed flask fitted with inlet and outlet tubes and thermometer, was subjected to a stream of ozonised oxygen. The preliminary experiments showed that the reaction was vigorous and could not be readily controlled. The gas was passed at about 1 litre in 4 to 5 minutes, and the material in the flask was agitated in order to expose a fresh surface constantly. In this way it was possible to keep the temperature below 35° C.; if the material were not so agitated the whole mass became hot and charred within 2 or 3 minutes. After several trials the experiment was so regulated that at the end of 2 to 3 hours the temperature had fallen and the reaction had apparently ceased; the material was now sticky, and the particles adhering together. It was then extracted with acetone and the ash determined by ignition.

Ash before ozonisation	50·25%
Ash after ozonisation and extraction	67·20%

It, therefore, appeared that 34% only of the organic matter had been rendered soluble by the treatment.

Several other steam vulcanised samples were tried, and the percentage extracted by acetone from the once-treated material determined by difference.

Pure Gum	40·1%
Cab Tyre	30·6%
Red Motor Tube	30·7%

In every case rubber was present in the extracted material.

It was thought desirable for further experiments to employ a filling material which could not conceivably take any part in the reaction either with the reagent or with the reaction product or products. As zinc oxide might possibly react with any acid developed, it was decided to substitute barium sulphate and employ the following mixing:

$BaSO_4$	67·0
S	3·0
Plantation Sheet	30·0
	100·0

With this sample the effect of successive treatments with ozone was determined, the reaction product being removed at each step by extraction with acetone. The results are given below in tabular form.

Duration of treatment. Hours.	Ash %.	Organic residue %. by difference.	Removed %.
0	66·5	33·5	—
4	82·86	17·14	48·8
2	87·45	12·55	21·3
2	89·13	10·87	13·4
2	90·78	9·22	15·2
2	91·29	8·75	5·5

As a result of these few experiments the conclusion must be drawn that there is little prospect of the ozone treatment furnishing a general quantitative method for the determination of mineral matter in rubber mixings or even in the particular case in view, for the following reasons :

1. (1) In many instances it causes alteration in the mineral matter.
2. (2) The organic matter is not readily or completely removed under the conditions described.
3. (3) The difficulty experienced in controlling the reaction.

While the result of this portion of the investigation is negative, the original work is being continued with a view to obtaining some insight into the nature of soft cured rubber, about which there is at present little definite information available.

It has been determined by Spence and others (Spence & Young, Z. Ind. Chem. Kolloide, 1912, xi., p. 28) that vulcanite corresponds to a definite chemical compound having the empirical formula $C_{10}H_{16}S_2$ and containing 32% of sulphur. The question naturally arises as to the nature of the apparently equally definite substance produced when only 2·5% sulphur is combined. If, as suggested by Hübener (Chem. Zeit., 1909, xxxiii., p. 144) a small proportion of $C_{10}H_{16}S_2$ is formed, it may be possible that this functions as a protective colloid conferring the property of resilience and insolubility on the remaining portions. It would, therefore, seem possible that, by means of ozone treatment, the unaffected caoutchouc might be removed, leaving a residue of the disulphide.

Some of the results obtained at the moment would indicate that such was the case, but more cannot be said as the work is not complete and is beyond the scope of the present paper.

In conclusion, the authors desire to express their indebtedness to the University of Edinburgh for the use of the ozone apparatus and access to the reference library.

THE CHAIRMAN : A paper has been handed to me at this moment that is so closely related to the one that has just been read that if Mr. Porritt has no objection I think I will have it read now, and we can take the two discussions together. This new paper is by Mr. Henry Williams Jones, and the title, " A simple method for the estimation of mineral matters in vulcanized rubbers," would not indicate that there is as much relation to the paper just read as the body of it reveals.

A Simple Method for the Estimation of Mineral Matters in Vulcanized Rubbers.

BY
Henry Williams Jones,
Chemist to the Dunlop Rubber Company, Limited.

The most tedious part of a rubber analysis and the one requiring most time is the separation of mineral and other insoluble constituents. Having tried the various known processes, of which I give a short summary, I have found a method which offers, I think, practical advantages.

over all others. Although simply based on the use of Acetone as a diluent, this liquid does not appear to have been previously used for this specific purpose, yet, it behaves in an altogether different and more satisfactory manner than benzol or any substance in common use. In place of turbid solutions having more or less material in a colloid state, we have clear solutions after a few hours time for deposition. Put on overnight, we obtain perfectly clear solutions ready for decantation on the following morning.

For the separation of the mineral matter in compounded and vulcanized rubber Henriquez employed petroleum with a boiling point over 150°C. Weber found it useless in rubbers highly vulcanized, as solution was not properly effected, and suggested and employed nitrobenzol, but apparently failed to obtain proper solution with compounds having a vulcanization co-efficient exceeding 4 per cent., and so gave up the use of nitrobenzol and used α -nitronaphthalene, kept at a temperature of 170° to 180°C. in a specially devised air bath. The caoutchouc was thereby decomposed, the solution was diluted with benzol, and the mineral matter with other insoluble material, filtered off after being allowed to deposit. The advantage claimed for nitronaphthalene was increased facility in the filtration process; since with nitrobenzol diluted with benzol, it was often found impracticable to obtain a clear filtrate. The difficulty experienced by myself and others with nitronaphthalene was the liability of the nitronaphthalene to crystallize out, especially with the proportions given by Weber. There remained then the only practicable method of nitrobenzol diluted with benzol, and allowing the insoluble matter to slowly deposit. The slow deposition often required a week or longer, to obtain a supernatant liquid sufficiently clear to allow of decantation. To overcome this great practical difficulty, not to be obviated by the use of the centrifugal, in the majority of cases, different solvents have been proposed.

Dr. Schidrowitz has advocated petroleum as a solvent, and has drawn attention to the fact that the rubber substance is not destroyed and allows, after filtering or settling, a determination of actual rubber to be made in an aliquot part. In practice I find this a very objectionable procedure. The use of petroleum with a boiling point of 230°–260°C. was given by Hinrichsen and Manassee in 1909, and in the previous year Frank and Marckwald made use of the autoclave at a pressure of 12 to 15 atmospheres, employing xylol as the solvent, ether being the diluent. Anisol and phenetol have also been proposed for effecting solution at 90°–120° (Hinrichsen and Memmler). With certain compounded rubbers, much time is required before a clear filtrate can be obtained even with prolonged digestion, so that the use of the autoclave is now being abandoned. Among the latest propositions, we have the method given in the preliminary report of the Joint Rubber Insulation Committee appointed by a group of American manufacturers. The process consists in extracting 1 gm. sample with acetone for five hours, transfering the residue to a tall, 200 cc. lipped beaker, adding 40 cc. terebene and 20 cc. xylol, and heating on an oil bath at 105–110° for about 20 hours, or until the bulk of the fillers settle promptly after stirring. The beaker is then allowed to stand until the minerals and undissolved materials have settled thoroughly, the supernatant solution is decanted. The undisturbed residue is further heated with 30 cc. terebene for several hours, decanted off and further treated with terebene and heat. Benzol is finally used for washing and the residue collected on a tared filter paper, and washed with hot alcohol, and acetone, then dried at 95–100°. Much time is occupied by this process which necessitates an evaporation, and ashing of the total solvents and washings to ensure the whole of the mineral matters being included, and which might be lost through matter carried through the filter.

A consideration of these various methods—all more or less unsatisfactory—induces me to record a new process of my own, based on a fact which I observed when experimenting with the products obtained by the action of nitrobenzol on pure rubber. I found that the residue from the nitrobenzol solution left by the somewhat slow evaporation on the water bath in a flat bottomed dish, or obtained in a flask by distillation under reduced pressure, was easily and entirely soluble in acetone. It occurred to me to use acetone for diluting the nitrobenzene solution. A surprisingly rapid deposition resulted on my first experiment, and this has invariably been the case with subsequent trials. The objection to the use of nitrobenzene on account of its decomposing action on sulphides of antimony and carbonates of calcium and magnesium has been, in my opinion, more fanciful than real, since I have shown that with both calcium and magnesium carbonates little or no CO_2 is eliminated by boiling in nitrobenzene up to a period of one hour, at least.

A further objection has been made to the use of nitrobenzol on account of the poisonous nature of its vapour, but the inhalation of such vapour is entirely obviated by solution in a flask under a reflux condenser, no current of cold water being required, as with a fair sized condenser the vapour returns as a liquid. The water surrounding the condensing tube remains only reasonably warm. With nearly all samples a small amount of water is split off and a hissing noise is produced when the condensed drops fall back into the flask. Operating on 2 grams of rubber with 40–50 cc., or more, of nitrobenzol in a 200 to 300 cc. flat bottomed flask, occasions no real difficulty from this source. After cooling, the flask is filled up with acetone, well mixed with a thin glass rod and allowed to deposit. The subsequent treatment consists of a further washing by decantation with acetone, transferring to a tared filter paper and continuing the washing with the same liquid. In some cases it is an advantage to wash further with alcohol and chloroform, and then to pass water through the filter, so as to obtain a moist and uncaked residue for further examination of its constituent parts. In general practice I find it sufficient to make two nitrobenzol residues and to use one for CO_2 and the other for the sulphur in the mineral matter.

The CHAIRMAN: In opening these papers for discussion I cannot refrain from departing from the usual procedure and putting a question myself at the outset, because it is of very great interest. At first sight the results obtained by Messrs. Porritt and Wheatley with the ozone method appeared almost incomprehensible. One would not have predicted in advance that the destruction of organic matter by the ozone would have slowed out as it did, and finally come to an end. When I came to look the paper over I found what had originally escaped me in the reading, that the residue after that time had altered its appearance and glazed over, and partially cemented together. May not the slowing down be a purely mechanical result? I noted also that Mr. Porritt spoke of the difficulty of carrying out the experiments in solution. That is true, because vulcanised rubber is insoluble. Does he not think that it might have altered conditions if he had merely put it in suspension? These papers are both extremely interesting, and I hope that you will discuss them fully.

Dr. WERNER ESCH : Please excuse me if I make some mistakes in my English, for I shall have some difficulty in expressing my meaning when dealing with these papers. I am one of those who are extremely interested in the analysis of compounds which contain a fair amount of magnesium in the form of oxide or carbonate, and I have for some years done much work on these lines. I am now bringing before you some observations which I have made, because I believe that they, being for the most part unpublished up to the present, will probably be of some value for the discussion and further work on this subject. I may mention first in speaking of the carbonate of magnesium which is used in rubber manufacture that the material employed for this purpose may vary considerably in composition, and that there exist some four or five substances sold under the title of carbonate of magnesium. Of course, these are always basic carbonates, but very considerable differences in properties exist between them. There are carbonates which contain only 40% of magnesium oxide, and others which contain 45%, and it is very difficult for the analyst to find out from examination of a rubber sample the real formula which was used by the manufacturer. Another matter with which we have to contend is that these carbonates of magnesium differ greatly in their points of decomposition. I have found many samples of the commonly used carbonates begin to decompose at 100° C. For the most part, at vulcanising temperatures of 130° C. they lose from 6% to 7% of CO_2 as well as a small proportion of moisture. The use of a solvent at an elevated temperature is, therefore, inadmissible for analysis. I have tried anisol and phenetole, which have been mentioned by Professor Hinrichsen. It is very difficult to obtain a correct analysis and he gives his results as MgO and Carbonate.

I know that in 1893 Henriques, in whose Laboratory I was trained used solid paraffin for his analytical work. Afterwards in 1898 he recommended the use of petroleum, which was subsequently also recommended by Hinrichsen without acknowledgment of the prior work. The method which we are using in our Laboratory at Hamburg is almost identical to the method which has been brought forward to-day by Mr. Williams Jones. I should mention that when estimating CO_2 we take great care to avoid the development of hydrogen sulphide by adding a certain amount of etheric copper chloride or reduced copper as an absorbent. In certain cases depending on the degree of vulcanisation we cannot proceed in this manner and employ turpentine agitated with a current of air at comparatively low temperature to effect solution.

In connection with our analytical work, we have found that formation of some magnesium sulphate always seems to take place in rubber goods containing large amounts of oxides or carbonates of magnesium. This also adds to the difficulty of finding out the mixing formula which is frequently desired by the rubber manufacturer.

Dr. PICKLES : We have listened to two extremely interesting papers. This method of passing ozone into the rubber is by no means new. The originality of the method outlined by Messrs. Porritt and Wheatley appears to consist in the use of the rubber in the dry condition, instead of having the material in suspension or pseudo-solution. Attempts to decompose the rubber in solution or suspension by gases of the type of ozone and nitrogen oxides have been previously proposed. Dr. Ditmar proposed that vulcanised rubber could be attacked in a similar manner by suspending in solvent and passing ozone through it. It would seem very probable that the unattackable residue obtained in the latter stages of the determination consisted of a portion of the rubber containing a relatively high proportion of combined sulphur. This might be expected, for the action of the ozone on rubber depends on the unsaturated condition of the rubber molecule. If by combination with sulphur this becomes saturated its attack by ozone will be comparatively slight. With regard to the paper contributed by Mr. Williams Jones, the addition of acetone to the nitro-benzene solution is of great interest, as it will tend to facilitate a slow and tedious process. Dr. Esch has stated that he uses ethereal copper chloride solution instead of the copper sulphate usually employed. I would like to know whether there is any particular advantage of this over the latter method for the estimation of CO_2 ?

Dr. Esch : The ethereal solution is exceedingly reactive. It penetrates quickly into the sample, which is a valuable feature in the case of the analysis of lightly compounded qualities, which are difficult to reduce to a finely divided condition. This method is not our own. It was found out by Henriques, and I learned it as his pupil.

Dr. Slocum : Has the well-known tendency of copper to promote the oxidation of rubber been used to accelerate the oxidising effect of ozone ? Finely divided copper is an admirable agent for the removal of halogens from ring structures. It might be likewise effective in the excision of sulphur from the caoutchouc aggregate. Has the sodium press been used on warm rubber to obtain a convenient physical condition for oxidation and other purposes ?

Dr. Esch : I may draw attention to a further point which is very important. We have found in our Laboratories that on treatment with bromine or nitrogen-dioxide a part of the so-called chemically combined sulphur is split off from vulcanised rubber. This is very noticeable when making comparisons between freshly vulcanised soft rubber and reclaimed rubber produced by the alkali process. In the former case the results by the bromine process, while in good agreement, give too low a value for the combined sulphur, and the co-efficient of vulcanisation determined by these newer derivative methods is extremely low in comparison with the results obtained by the so-called difference method. Ozone would probably behave in the same way. Moreover, it is possible that when ozone is employed for decomposing the rubber molecule to render it soluble some of the sulphur may be oxidised to SO_2 or SO_3, which will combine with the alkaline constituents of the mineral matter. I also ought to add that although I stated earlier that we use a method approximating to that of Mr. Williams Jones, this is not altogether correct, as we modify the method according to the nature of the sample under analysis, and whenever possible we employ several distinct methods and take the mean of the results.

Mr. F. G. Edmed : Has Mr. Porritt ever made any direct determination of CO_2 in the sample ? By that means you can get a result sufficiently approximate for ordinary works purposes. At the beginning of his paper he mentioned the estimation of antimony sulphide and the importance of its estimation in view of the prevalent 11% specification for which I think I am more or less responsible. We came to the conclusion that for all ordinary purposes one can get quite a good value by simply boiling out the finely rasped sample for several hours with moderately concentrated hydrochloric acid. The antimony estimated in this way in solution has always given higher results than when estimated by the oxidation methods.

Dr. Esch: Yes, I confirm that.

Mr. Edmed: With regard to the magnesium, that is a problem always confronting us. I should like to confirm the statement that magnesium carbonate does not suffer serious decomposition when the rubber is dissolved in solvents such as paraffin wax at temperatures of about 170°–180° C. I have used Henriques' paraffin wax method for the direct determination of mineral matter, but the great objection is, of course, the difficulty of obtaining good filtering solutions.

Mr. Porritt: Dr. Torrey has referred to the slowing down of the effect of ozone on rubber, and suggests that this may be due to the formation of a protective coating. I should say that this applies during the first treatment, but by the time one has only some 10% of organic matter left the sample is scarcely distinguishable from zinc oxide and is quite devoid of adhesion even after treatment. This possibility was one of the reasons which made us anxious to carry out the treatment by suspending the sample in a suitable liquid, and we tried some experiments in this direction, making use of chloroform. The results, however, were very unsatisfactory, as only slight action took place after treating 12 hours, probably owing to the sparing solubility of ozone in this solvent. We have not yet, however, investigated the action of ozone on various other suitable solvents, and possibly may find one in which the action will take place readily without the present danger of heating, and which will effect solution of the oxidation products as they are formed.

With regard to what Dr. Esch has said in reference to the variety of magnesium carbonates, the investigation by Brill which I have quoted deals, I think, with four or five varieties, but in works procedure I have examined numerous samples from different sources, and have always found remarkable uniformity in the magnesium oxide content, but, of course, the same may not apply on the Continent.

The possibility of decomposition will depend on the particular basic carbonate employed, and is certainly quite possible at vulcanising temperatures, when the reaction would be assisted by the well-known solubility of carbon dioxide in rubber.

We are at present working on the lines suggested by Dr. Pickles, and some preliminary experiments with ozone on ebonite which we have carried out appear to show that the attack is very slight. This work is being continued when the sulphur, both in the soluble portion and the residue, will be estimated at each step in order to ascertain exactly what happens to the combined sulphur.

In connection with estimation of antimony by direct solution in hydrochloric acid, I regret I have not had any experience of this method, and I am afraid I should be somewhat prejudiced against it in view of the tenacity with which rubber retains traces of acid and alkali. The method to which I have referred was found to be generally applicable, and, after careful blank determinations, we decided on it as reasonably quick and free from any possibility of error.

The use of copper as a catalyst did not occur to us, and I can, therefore, say nothing regarding its effect. It has already been observed that copper appears to promote oxidation and perishing, and is, therefore, an undesirable constituent in mixings.

The Effect of Acids and Alkalies on Rubber, more especially in Relation to Reclaimed Rubber.

By
W. G. MARTIN.
Experimental Department, North British Rubber Co., Ltd.

It is a fact, well known to rubber manufacturers and others connected with rubber reclaiming, that there are many methods which have been used, and are still in use, for the process of reclaiming vulcanised rubber. The aim of all these is, of course, to produce an article as nearly resembling crude new rubber as possible. Up to the present this has not been attained. The fundamental of these processes, and of the scientific standpoint, is the separation of the sulphur from the rubber—which, according to some, is adsorbed, and to others, is chemically combined. It was known, of course, that caustic alkalies dissolved sulphur, and no doubt this was tried on rubber with this idea in view. As is well known to those connected with the rubber industry, the alkali only removes the sulphur which is present in the free state, *i.e.*, that sulphur which is not combined chemically with or adsorbed by the rubber, whichever point of view is taken. At least, the residue of rubber after treatment with alkali does not show the property which is chiefly characteristic of the unvulcanised article, *i.e.*, solubility in solvents, *e.g.*, naphtha, benzene, etc. Nevertheless, the process of treatment of vulcanised rubber with caustic alkalies remains, and yields a stock which, judging by the enormous quantities turned out by alkali plant, gives good results. Under the heading of treatment with alkali, comes the salts of alkali metals which produce alkali *in situ*, so to speak. However, the basis of the chemical reactions involved in the use of them is: (1) destruction of fabric present, (2) conversion of free sulphur into some sulphur compound. The product is then subjected to heat. This, in a very condensed form, is the main feature of the alkali process.

We now turn our attention to another process, important in the reclaiming of rubber, that known as the acid process. It is difficult to trace the facts leading up to the use of acid in reclaiming, as acid of any description is one of the substances which is usually attributed as being one of the bugbears of the rubber manufacturer, from several points of view. It is supposed that the deleterious action of acids on fabrics—a huge amount of which must necessarily be treated in dealing with reclaimed rubber—probably led up to its introduction and use as a reclaiming agent. In this case, however, it cannot be said that acid acts on sulphur in the same way as alkali does, and apart from the very small percentage of sulphur lost by mechanical working the whole of the sulphur remains in the finished article. In fact, with some brands of acid reclaims it is possible to vulcanise the reclaimed rubber without the addition of more sulphur, and simply relying on the sulphur present in the reclaimed to do the work. In effect the acid system of reclaiming consists in destroying the fabric with acid, followed by a heat treatment. It is well-known to people in the rubber and rubber reclaiming trades that the treatment by alkali and acid is really a preliminary in the whole process. The heating process is that which produces the softening effect, and imparts to the rubber a dead and lifeless appearance when in the unvulcanised condition. The heating is carried out by means of live steam at high pressure. The addition of oils is often—in fact generally—made to produce various kinds of reclaims and to impart a certain amount of stickiness or tack to the finished article. More will be said in connection with the addition of oils to reclaims later in this paper.

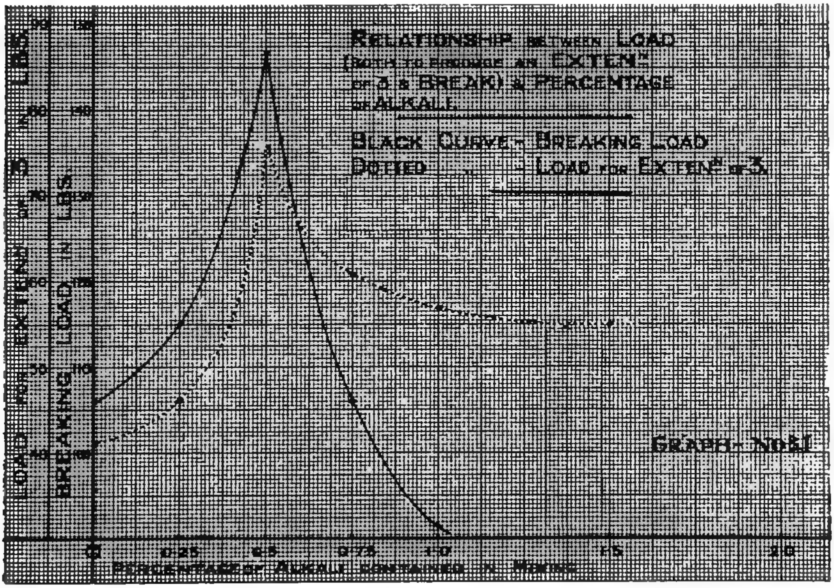
The foregoing will give a brief outline of the two processes involved, and which it is now proposed to treat more on the lines of the title of this paper, viz., as to the effect of acid and alkali on the reclaimed product. The first question one naturally asks is, as to how the alkali or acid becomes left in the reclaimed rubber. To those connected with reclaiming the answer is well-known, viz., that to wash out last traces of acid and alkali is practically impossible. Naturally, the acid cannot be neutralised by washing with alkali, and *vice versa*, else the latter remains to be washed out, and naturally the reclaimer washes as thoroughly as possible with water. It has been found, however, that despite careful washing, samples of alkali reclaimed rubber, in the unvulcanised condition, have contained as much as 0·5 per cent. alkali.

The second question follows from the first. Even if there is this amount of alkali, how is that going to effect the reclaim in use? Now, that is the point it is proposed to follow through. It was decided to work with new rubber and study the effect of small amounts of alkali on this in the first instance, and to keep the mixings employed as simple as possible in order to eliminate errors arising through complications caused by possible interaction of ingredients amongst themselves. It was decided also to use only such mineral fillers as were inert, and produced no accelerating action on the vulcanisation of the samples. Such fillers as litharge, magnesia (carbonate and oxide) and lime were therefore studiously avoided, and in the first instance the following mixing was used. This consists of

H.F. Para	38¼%
Zinc Oxide	60 %
Sulphur	1¾%
	100

This mixing will be recognised as the Admiralty 8c quality. It was chosen on account of the small amount of sulphur it contained. The ground for this is that a compound containing a small amount of vulcanising agent will show variations in cure better than a compound containing a large percentage. This, it is thought, is a point which should always be borne in mind in comparing vulcanising properties of rubber, viz., to use a mixing containing inert mineral fillers (non-accelerators) with a low percentage of vulcanising agent—sulphur.

This mixing was taken as a basis, and a batch of 25 lbs. was put down. This batch was divided up into smaller batches, and caustic soda was added in a finely powdered form. The soda used was chemically pure, in the stick form, and was powdered in small quantities at a time, out of contact of air as far as possible on account of the absorption of moisture. By this means six small batches were formed, containing respectively ¼%, ½%, ¾%, 1%, 3% and 5% of caustic soda. One batch was kept, containing no caustic soda, to serve as a blank or reference. The next point to be considered was that of the vulcanisation. It was finally determined to cure by hydraulic pressure at a steam pressure of 50 lbs., corresponding to temperature of 297° F., and furthermore to cure over a range of time varying from two to three hours. This was fixed upon, as the sample containing no alkali cured to give the best tensile tests at about 2½ hours—midway between the limits set. The actual times of cure were 2 hours, 2 hours 20 minutes, 2 hours 30 minutes, 2 hours 40 minutes, 2 hours 50 minutes, and 3 hours. At each of these cures three test pieces of the above seven compounds or mixings were cured, and any result expressed as tensile stress or strain in this paper is the average of the three test pieces in question. In the testing of these samples and of others mentioned herein the following system was adopted: The test piece was stretched to three times its original length, and the load necessary to produce this elongation was duly noted. The sample was then further extended until rupture occurred, at which point the load and elongation were again noted. The load required to elongate the test sample three times its original length is regarded as a measure of the state of the cure, to a certain extent, and serves as a check or confirmation of this point, as indicated by the breaking load. The results of these tests are indicated in the following curve, which serves to express in a graphical manner the variation in rate of cure. The latter, of course, is caused by the presence of alkali, as all other factors are common to each mixing, individually.



Expressed verbally, our experience shows that the presence of alkali up to 0·5% decidedly accelerates vulcanisation. Above that amount, strange as it appears, the rate of vulcanisation is retarded, and, in fact, the presence of 5% alkali so affects the cure as to make it impossible to vulcanise the sample in the time specified. In fact, samples were not even half cured. It may be urged that the alkali and zinc oxide reacted at the temperature of vulcanisation, but to preclude this possibility having an influence on the results, the same ground was gone over, using barytes in place of zinc oxide. The results were identical, so that the formation of zincates or compounds of that nature is concluded not to have taken place, and not to have influenced the result.

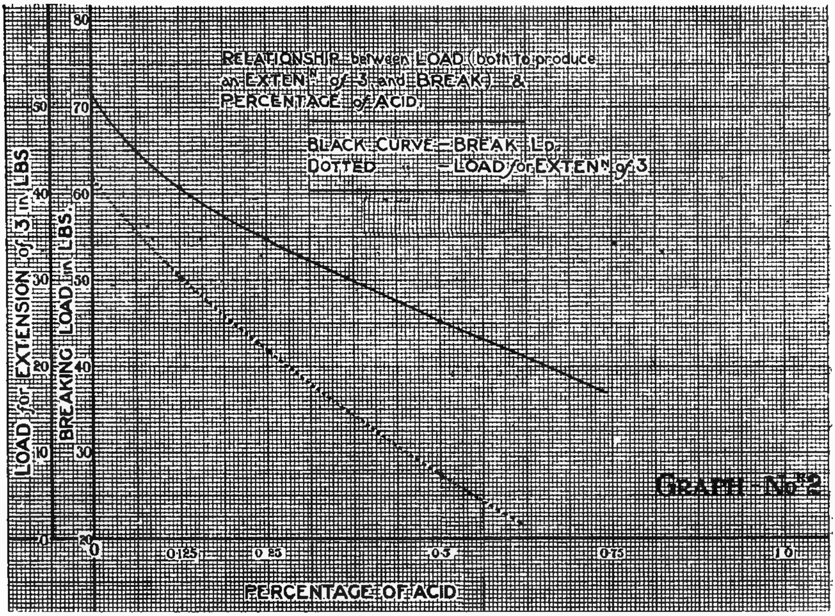
Turning to the case of acid residue in rubber reclaims, it was determined to test the effect of acid in a manner similar to that explained previously for alkali. However, the acid used in reclaiming is as a rule sulphuric acid, and the mixing of this material gave us at first some little trouble as to the mode of its introduction into the mixing, which in this instance was the barytes one beforementioned, viz. :

Barytes	60 %
Sulphur	1¾%
H. F. Para	38¼%
	100

It is stated that sulphuric acid is mixed with hydrochloric acid or with common salt—sodium chloride—in the acid process in some works. The idea here is to form chlorides of the mineral constituents present in the reclaim under treatment. These, being soluble in water, are washed out in the subsequent processes, and thus the mineral contents of the reclaim is reduced, and consequently the rubber percentage increased. Working on a grade of reclaim made from Russian shoes, it was found possible to reduce the mineral matter percentage by 33%, with an increase in the rubber content accordingly. As to whether the process is actually used, is a point upon which I cannot say definitely, but the cost of hydrochloric acid probably more than balances the increased value of the reclaim.

The use of zinc oxide was precluded on account of the formation of zinc sulphate by the reaction of zinc oxide and sulphuric acid. The method finally adopted was that of sheeting the mixing thinly on the mill, and removing same in this form. A few drops of concentrated sulphuric acid were then smeared over the sheet, and the latter was rolled up into a shell-shape, and this was passed through the mill several times until mixed thoroughly. The correct percentage of acid was introduced by performing the operation four or five times in the case of the higher percentage of acid. By this means the mill rolls were scarcely attacked by the acid. Samples were checked after milling by means of repeated washing with water, and subsequent estimation of acid in same. In addition, one mixing was run containing only ⅛% of acid. In this case the range of cure was made from two hours to four hours.

The result of the tests on these samples gave the following curve, which, briefly stated, means that the presence of acid retards, or makes vulcanisation slower. The effect of the introduction of ⅛% sulphuric acid is really remarkable, and the difference between the samples containing no acid and ⅛% acid was distinctly noticeable to the feel, such as stretching or bending the test piece by hand. It is only fair to say that the compounds containing 1%, and 3% acid showed distinct signs of porosity, no doubt caused by the action of heat on the acid.



THIS CURVE SHOWS THAT THE EFFECT OF THE INTRODUCTION OF ACID HAS BEEN TO RETARD THE VULCANISATION OF THE RUBBER.

Now from these results it is seen that the presence of acids and alkalies in rubber has a decided effect upon vulcanisation, and it is fair, I think, to assume that the effect on new rubber is identical with that on reclaim. However, some people may not be prepared to go that length, without further tests on actual reclaimed rubber, and it is proposed to put these in hand on the first favourable opportunity. One point remains, however, which will appeal to all. Reclaims are mixed with new rubber, and thus alkali and acid reclaims will serve as a means of introduction of alkali and acid into new rubber. Therefore, suppose that two deliveries of reclaim vary in alkali content, what will the effect on the cure be, for example ? " Variation in cure " is the answer ; one of the points rubber manufacturers have to contend with most seriously. Admittedly, the controlling of the amount of alkali present is a difficult matter and hence means should be sought by which this difficulty might be removed.

With this point in view it is suggested that the introduction of a saponifiable oil may be of service in this connection, and work is already in hand on these lines.

In concluding this paper, a most important point may be emphasised namely, that rubber is very susceptible to the influence of various substances, even in very small quantity, and this should be borne in mind always. As an example, the present paper shows how such a small quantity of acid and alkali, even to the extent of $\frac{1}{8}\%$, has very materially affected the most vital of all the properties of rubber, vulcanisation. In this connection it may be stated, although perhaps somewhat outside the scope of the title of this paper (nevertheless, the point is one bearing a close relationship), that the substitution of acetic acid for sulphuric acid in these experiments decidedly retarded the cure, but not to such an extent as the sulphuric acid. In addition, the extensibility of samples containing the higher percentage of acetic acid was markedly impaired. This in relation to plantation rubber, in which acetic acid is used for coagulating purposes, needs no emphasis from me as to the importance of such a factor.

The CHAIRMAN: We have listened to a paper just now on a subject that has never turned up at these conferences before, and one on which, unfortunately, there is very little literature of any kind. It seems difficult to believe that this is due to lack of experience or knowledge. I am sure there must be those who have experience in this same line, and it is a paper that should bring out some very useful discussion.

Dr. ESCH: May I ask Mr. Martin if he has noticed, in his experiments, in adding a certain amount of sulphuric acid after vulcanisation of his sample, which did not contain zinc oxide or any other neutralising agent, a salt smell and a kind of porosity or sponginess in his samples. I have found these things in tests of the same sort.

Dr. SLOCUM: Was any attempt made to extract your acid to determine whether sulphuric acid or caoutchouc acids had been formed? I would also like to know, in regard to the experiments with alkalies, were your samples overcured or did the stretch go up with the increase of tensile strength?

Mr. MARTIN: In reply to Dr. Esch, I can state that small amounts of acid up to 2% brought no signs of porosity, but there was a distinctly acid smell and taste. Quantities above 2% caused porosity. In reply to Dr. Slocum, I have to say that no attempt was made to investigate the possible formation of sulphuric acids with the rubber hydro-carbon, or to see whether the sulphuric acid was in a free state. We shall be able to investigate it in the future, and I am grateful for the suggestion. With regard to the same gentleman's question as to breaking strain, it distinctly improved, but the elongation seriously diminished. The samples containing the maximum amount were doubtless overcured.

Dr. ESCH: Is it not possible that the small additions of free sulphur in your test compounds may have been responsible for the strongly marked point of inflection in your curves. It may be that the action between the residues of the acids took away so much sulphur from the action of the rubber that only a very small amount of sulphur was left for the real cure of the rubber. I mention this especially because of an observation in an old paper of Dr. Christian Heinzerling, published in Germany in 1883, regarding the manufacture of rubber goods and gutta-percha goods. In making his suggestions for improving the qualities of low grade rubbers, and especially African rubbers, which at that time began to be supplied to the trade on a bigger scale, he set down that the tackiness of African rubber could be got rid of by boiling with sulphide of potassium. I do not know whether experiments have been made by anybody along this line, and if by boiling rubber in sulphide of potassium an addition of sulphur to the rubber takes place. If it does it would be impossible that the bigger amounts of alkali added in your tests here should paralyse the small amount of sulphur. But if the alkaline sulphides do not give off sulphur to the rubber so that the rubber becomes vulcanised, I do not see a good explanation for the effect of the alkali, because small amounts seem to have an ameliorising effect to such a degree that you have an overcured sample in the case of that one containing ½%.

The CHAIRMAN: I am very sure that at some time I have seen a statement that the use of alkali sulphides has actually been employed as a method of vulcanisation.

Dr. ESCH: You mean perhaps the method patented in France as Girard's patent, for the use of a hydro-sulphide of calcium as a very effective means of vulcanising? It must be a fact that sulphides or polysulphides of sodium and potassium are useful for vulcanising.

Mr. MARTIN: Dr. Esch's question may be taken perhaps more or less as a statement. In connection with the alkali reclaiming it is found that there is practically no free sulphur in the alkali liquor. Most of the sulphur which has disappeared is in combination with the mineral constituents of the rubber itself. That may probably be what has occurred here in connection with the high percentages. The high percentage of alkali has probably been one cause of reaction with the sulphur, and between the zinc oxide and the sulphur, and has diminished the amount of available sulphur for vulcanisation.

Dr. ESCH: I have always found, even in samples only vulcanised with zinc oxide and sulphur, that a certain amount of zinc sulphide has formed.

Dr. LOEWEN: How have you tested the diminishing of the vulcanising effect in these samples? Is it only by mechanical means? I would also like to know if you have proof that the amount of combined sulphur was diminished too? There is a certain difference between these two methods. It may be that the amount of combined sulphur is equal even if the mechanical properties have not increased in the same way.

Mr. MARTIN: The testing was done by mechanical means only. No attempt was made at a solution of the problem from an analytical point of view.

Mr. BURNARD: Assuming that some other form of coagulation by smoke is employed, and it is desirable that coagulation should be arrested by use of formalin, is there any objection from the manufacturer's point of view to the use of that substance?

Mr. MARTIN: I think a good deal of work is being done with regard to the effect of the various coagulating agents used by the plantation companies. Mr. Williams, of our company, is working in connection with sodium bisulphite, and some people probably are at work on the question of formalin, and no doubt in due course their results will be published. At present I am not able to say whether formalin is objectionable or not.

Variability.

By

PHILIP SCHIDROWITZ, Ph.D., F.C.S.

The CHAIRMAN : In introducing this extremely important paper, I am going to follow an unusual procedure and put in a word of caution beforehand, because it is essential that all that is said should be well considered and to the point. In the discussion that is sure to be aroused we should not wander from the subject. In the first place the paper is written on an assumption that a certain state of things exists. What that state of things is you will find clearly indicated. It assumes that plantation rubber is variable. However, we will be well advised to let that particular point alone. The very next paper, coming from Mr. Williams, will give us an opportunity to discuss it *ad lib.* The sole question that we should discuss in this one arises from the fact that the paper proposes a certain method of evaluation of rubber by which it is hoped to eliminate the state of things that it is assumed exists. The only thing you have to consider in this particular discussion is as to whether the principles on which the proposed method is founded are sound, whether the application of the method is practicable, and in the third place whether it will accomplish the effect it is supposed to accomplish. If not, what will it accomplish ?

Dr. SCHIDROWITZ : This paper is only to be regarded as quite preliminary. The full details of the methods to be employed, and which have been employed for some time in my laboratory, will be published very shortly, possibly in the autumn. The work in this paper has taken several years to shape, and the work of getting such information ready does not fit in conveniently at all ordinary times for one who has a good deal of routine and research work to carry out. I wish particularly to call attention to the fact that this paper is only in a sense a preliminary communication.

It is now just a year since I called attention in a paper on " The Future of the Rubber Industry "* to the importance both to the producer and the manufacturer of the variability in essential and inherent properties of plantation rubber. Suggestions were made in the course of the paper referred to as to how the difficulties associated with this question might be overcome or dealt with. These suggestions in an amplified and more detailed form were subsequently considered by the Standardization Committee appointed by the Rubber Growers Association. After hearing evidence from manufacturers and others qualified to give an opinion on the proposals of the writer, these were unanimously adopted by the Committee, both as regards general principles and methods. It is not my intention in this paper to rediscuss the whole question of variability, its importance and bearing.

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* cf. *R.G.A. Reprint* and *India-Rubber Journal.* June 28th and July 5th, 1913.

My object is to give a brief general account of the principles underlying the methods of evaluation by vulcanization tests suggested by me and approved by the Committee, and to indicate on general lines the extent of variation ascertained in practise by these methods over a considerable period. A full account of the work carried out in this connection with my colleague, Mr. H. A. Goldsbrough, F.I.C., F.C.S., will be published, I hope, at an early date. I had hoped to have the complete paper on this investigation ready for this Conference, but, unfortunately this has not been possible owing to pressure of other work.

I.

VULCANIZATION TESTS AS A MEANS OF MEASURING VARIABILITY AND AS A BASIS FOR EVALUATION OF QUALITY.

Curing Capacity and Rate of Cure.

If any rubber* is mixed and cured under any given set of conditions of (*a*) mixing, (*b*) calendering, (*c*) vulcanizing, and a number of cures be made under the said conditions, every factor excepting *time* being kept constant, it will be found, as is well known to most manufacturers, that one, and only one, of these cures will give better results than any of the others. If the intervals of time have been appropriately chosen, it *may* be that the cure showing the best result of the series is actually the best cure possible under the given set of conditions. Unless, however, there is some means whereby the theoretically best cure can be picked out, this is not necessarily the case. To emphasize this point, it may be stated that differences in rate of cure amounting to more than 300 per cent. have been noted between plantation rubbers of much the same *apparent* general character. In other words, it has been found that while some plantation rubbers cure perfectly (under certain standard conditions of mixing and curing) in *one hour*, others are still undercured at the end of three hours and more.

It is generally agreed that the only reliable method of comparing different rubbers with one another is by the examination of the vulcanized products, but it is obvious that such a comparison must be misleading unless it is applied in each case to the best possible cure.

Any system on which a commercial evaluation of quality is to be based, must have regard to the following points:

(1) The system of mixing, calendering and curing must be such as to exclude any material errors due to method (control of power, heat and pressure, etc.).

(2) All factors excepting *time* being kept constant, it must be possible to pick out with certainty and rapidity the best possible, that is to say, the "perfect cure" for the given conditions.

(3) The tests applied to the "perfect cure" products must be of an appropriate character.

Ad. (1). Means have been devised to reduce the influence of the human element in mixing to a minimum. (This is mainly of importance in regard to a large testing station).

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* This statement deals, generally, only with plantation rubber; but broadly speaking, it applies to any kind of high-grade Hevea rubber.

There is no difficulty in obtaining a test piece displaying a maximum variation in thickness of $\pm$ 1% to 1.5%.

It has been found practicable to regulate temperature to within $\pm$0.5° C.

Ad (2). While, in the past, there has been considerable scientific study of the chemistry of the vulcanization process, there is comparatively little in the published records on its physical or mechanical aspects, and there is much reason to believe that a systematic and thorough investigation on these lines has been the exception even in the case of comparatively large manufacturing concerns. This is all the more remarkable if we remember that rubber goods are mainly sold on account of their physical and mechanical, and not of their chemical properties.

Working in conjunction with others* the writer has found that:

(1) The process of vulcanization is physically and mechanically of a definitely progressive character and that its progress can be accurately expressed graphically by a series of stress-strain curves.

(2) The state of cure of a given mixing of any rubber at any given time (assuming standard conditions) is graphically expressed by the form of the corresponding stress-strain curve. The stress-strain curves representing progressive cures bear a certain mathematical relationship to one another for any one rubber, and what is equally important, a relationship exists between the series of curves representing progressive cures of any one rubber and the series of curves representing progressive cures of any other rubber.

Briefly stated, the relationship between curves representing progressive cures of the same mixing (taking a system of co-ordinates) x (load and ordinate) and y (elongation and abscissa) is:

(*a*) As curing proceeds the curves come further down the paper in regular fashion and do not cut at any point.

(*b*) At a part of the curve not far from the point of inflection the curves become parallel to one another, or in other words, for an equal increment of load there is an equal extension in each curve. That is to say, the rate of stretch decreases with increasing loads and is independent of the state of cure.

(*c*) The curves, referred to Cartesian co-ordinates, have been found by E. Hatschek to correspond to

$$y = a - b.\sin.\alpha$$
$$x = n\ (a.\cot \alpha - b.\cos \alpha)$$

In any set of curves representing progressive cures, a and b vary according to the state of cure, and a.n. is a constant independent of the state of cure.

(3) The relationship between a series of curves representing progressive cures of any one rubber and a series representing any other rubber is represented (*a*) by the value of the expression a.n., which corresponds to slope or type. Moreover, there is in every set of curves a specific curve in which a = b, or, expressed differently, every set of curves comprises a particular curve in which a and b are the same (and equal), but a.n. may vary.

As, in "rubber terms," a (for want of a better expression) represents the inverse of stretch capacity and b the limit of extension, it is obvious that the curve in any series for which a = b corresponds to a theoretically ideal balance of properties.

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* *Note.*—It is proposed to publish full details at a later date (*a*) in a general paper by Schidrowitz and Goldsbrough, and (*b*) in a separate paper by E. Hatschek and the latter on the purely mathematical part of the work.

(4) It has been found by experiment that the cure in any series represented by the curve in which a = b is actually the cure which gives the best results as regards tensile properties, etc.

(5) As a result it has been found perfectly simple by means of a single preliminary cure to deduce the exact form of the curve for the best cure of any rubber and so find the *time* of that best or " perfect " cure.

(6) It is possible, therefore, to obtain with rapidity and certainty the *best* vulcanization result that any given rubber can show.

A consideration of the above will lead to the conclusion

(1) That we are able with certainty and rapidity to *measure* the curing capacity or rate of cure of any given rubber on a comparable basis.

(2) That we are able rapidly and certainly to make the best vulcanized product that any given rubber can produce, on a comparable basis.

(3) That a direct comparison of quality between different rubbers may be made according to

(*a*) Rate of cure.
(*b*) General tensile and other properties determined by direct tests on " best cures."
(*c*) Properties represented by form and type of curves.

and that such comparisons are all capable of accurate measurement.

IMPORTANCE OF RATE OF CURE.—It is probable that manufacturers have experienced more trouble and financial loss as a result of the wide variation in *rate of cure* of plantation rubbers (*apparently* of the same quality) than from any other cause. The rapid deterioration of goods, sometimes in the case of very large lines, ascribed to " acid " in the rubber, to immaturity and so on, has, as likely as not, in many instances been ascribable to the simple fact that the goods have been markedly under or over-cured.

A manufacturer buys, say, a batch of smoked sheet, works it into a mixing, and ascertains the cure which is about right. The goods turn out well. He buys another lot of smoked sheet—of *apparently* the same grade and quality—and uses it in the same manner as the first batch. Now it is quite likely that the second lot may differ 100 per cent. or even more, in regard to its curing capacity, and, as a result the goods are spoilt and only fit for " scrap," or, and this is far more objectionable, their inferiority is not noticed until complaints are received from the customers and batches are returned to the works.

There is only one method of overcoming this difficulty and that is by applying to each batch of rubber a test which will accurately measure the rate of cure on a comparable basis.

Curing speed is important from other points of view. To a minor extent from immediate economic considerations; that is to say, for instance, a rubber which cures twice as fast as another will enable the manufacturer to put more stuff through his plant, and will involve a certain saving in wages, power, heat and so on. This may mean a difference in value of 5 per cent. to 10 per cent. in the works, according to circumstances and the class of goods handled.

From another point of view, *rate of cure* is of far greater importance, namely as a measure, in certain respects, of actual quality.

Within certain limits, rate of cure bears a direct relationship to quality and value, a slow rubber yielding goods which, compared with those made with a rapid rubber, are inferior in regard to stability and keeping properties generally.

The process of vulcanization constitutes (physically) a building or "firming" up, or to use scientific terms, aggregation or pectisation. Heat and mechanical working have the reverse effect; they have a breaking down or degrading action. It is obvious, therefore, that the less heating which a rubber undergoes at any time during the process of manufacture, the better. If two rubbers, the one fast, the other slow, are to be cured so as to attain as far as possible to the same physical properties*, the slow rubber experiences the disadvantage due to the comparatively longer heating, and its stability is thereby affected. It has been found experimentally that the effect on mechanical properties due to vulcanization is of exactly the same order as the "phenomenon of 'recovery' or 'ripening'" after mechanical working. It is not practicable to state the facts more fully here, but it is interesting to note that theoretical considerations, direct experiments by the writer and his colleagues and others, and the practical experience of many manufacturers consulted, all lead to the same conclusion as to the importance of rate of cure, and its relationship to stability.

TESTING.

Having ascertained the rate of cure and type, suitable strength and distensibility tests are carried out on test pieces appropriately cut from the best cure.

A system has been worked out according to which a certain number of marks is allocated for each attribute (tensile properties; rate of cure, physical condition and stability; *type* as representing inherent mechanical properties, such as capacity for work, elasticity, resilience).† The total number of marks may be conveniently returned in the form of an Index Figure of Quality, taking 1,000 as the standard. It was at first suggested—as the result of considerable experience in practice—that it would be sufficient with a view to a general commercial classification, to record on the proposed Certificate of Quality no more than the Rate of Cure and the Index Figure corresponding to every half ton lot sampled. A number of manufacturers, however, have suggested that it would be desirable to record the number of marks for each attribute, more particularly as it is quite possible that two rubbers might exhibit the same gross Index Figure, but that this may be made up quite differently. I can see no objection to this course; indeed, it has the added advantage that each manufacturer, whether he agrees with the number of marks allotted for each attribute or not, can form his own opinion on the correlation between such marks and his works practise.

SUMMARY.

THE SYSTEM OF TESTING PROPOSED ENABLES US:

(1) To ascertain and measure the comparative rate of cure.

(2) To obtain the *best possible* vulcanized product.

(3) To test the vulcanized product obtained not by any haphazard method, but as a result of the best possible cure.

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* Or, in other words, to their best or "perfect" cures.

† Marks are added or subtracted on a conventional basis according as the rubber is deficient or superior in each respect.

(4) To record and to measure and to express numerically, rate of cure, tensile properties, type, etc.

(5) To sum up these various properties in the form of an Index Figure of Quality.

Object of the Proposed Tests.

The main object of the scheme, so far as the manufacturer is concerned, is to place him in the position to choose the exact grade of material he requires ; that is to say, if he buys a lot of smoked sheet or crepe, etc., of a certain Rate of Cure, Index Figure, and so on, he is practically assured that it will behave in the works in the same way as any other lot of the same grade, rate of cure, etc. After a period he should be able to correlate the data given in the Certificate of Quality with works results and then the Certificate of Quality will also serve as a standard of value.

A number of practical questions, of which the following examples are typical, have been put to the writer :

(*a*) Does the "rate of cure" apply, say, to mixings in which such accelerators as Litharge, Magnesia or Lime are employed ?

The reply is that a rapid rubber will cure more rapidly than a slow rubber, whatever the mixing. Naturally, by employing, say, more litharge with a slow than with a rapid rubber, the best cure of the slow rubber can be approximated, as regards *time*, to the rapid rubber, but the resultant goods can never be of the same character ; indeed, they must, in general respects (hardness, gravity, keeping properties) be substantially different. By measuring the rate of cure we are gauging certain *inherent* properties of the rubber itself, and are thus able to compare it as regards those inherent properties with any other rubber.

(*b*) Does the system apply to rubber used for cold-cured goods ?

Here again it is to be remembered that we are measuring, on a comparable basis, the most important *inherent* properties of rubbers, therefore the same general principle applies to rubbers to be used for cold-cured as for hot-cured goods. Again in the case of cold-cured goods, a manufacturer will use for a certain purpose only a certain *type* or commercial grade, and within this comparatively narrow range (referring particularly to rubbers for cold-cure) the determination of a rubber's main properties should, in the vast majority of cases, be sufficient for all practical purposes as a guide to quality and value.

(*c*) Will the vulcanization results obtained by the standard methods of curing equally apply to or reveal the results obtained by the other methods of curing, *i.e.*, assuming that we vulcanize in a mould, may not the results be different (comparatively) if we cure in open steam or by dry heat ?

This question clearly indicates that the questioner has not recognised the essential difference between

(1) Testing a specific rubber of any type as to its behaviour under varying factory conditions.

(2) Testing a specific rubber of a specific grade with a view to ascertaining its inherent properties and comparing it accurately in this regard with other rubbers of the same type.

The proposed system of evaluation does not strive to determine the comparative quality or properties of any and every type of rubber, including wet, dirty and resinous Africans, Centrals, etc., but to determine sufficiently accurately for all commercial purposes the inherent properties and behaviour of substantially one grade of rubber, namely, of high-class plantation Hevea. Plantation rubbers, if we exclude the lower grades of scrap, are practically all dry and clean, and for and within each class (smoked sheet, crepe, ordinary sheet, etc., respectively) the variation as regards chemical composition* (resin, nitrogen, acidity, ash, etc.) is, as a rule, so small as to be negligible. Where there is any marked chemical variation this must surely affect vulcanization results. It follows then that if, for example, we have two samples of crepe which exhibit the same rate of cure, and if the physical and mechanical properties of the vulcanized products are (within the limits of experimental error) identical, that these two rubbers will almost certainly behave in exactly the same way, whatever method of curing or mixing is employed. It follows, further, that if a manufacturer has found a pale crepe or smoked sheet of a given rate of cure and index figure, etc., to be suitable for a certain purpose, that any other lot of the same grade with the same rate of cure and index figure, etc., will prove equally suitable for his work.

II.

EXTENT OF VARIABILITY.

It may be remembered that at the last Exhibition (1911) held in this country, several sets of rubber entered in connection with various competitions were examined chemically and by means of vulcanization tests. One of these sets comprized 46 samples, representing 24 estates. The following figures throw an interesting light on the extent of variability displayed by the series in question :

Total Number of Samples	46 ;	Number of Estates	24
Number of " Smoked " Samples ..	23.		
Number of " Unsmoked " Samples..	23.		

	Vulcanization Test. (Marks : Maximum = 70).
All Samples Greatest Variation	70 to 27
Variation for Smoked Samples	70 to 27
Variation for Unsmoked Samples	67 to 38

Samples Grouped According to Marks for Vulcanization Tests.

Marks.	No. of Samples.
65 to 70	4
60 „ 64	2
55 „ 59	7
50 „ 54	10
45 „ 49	12
40 „ 44	8
35 „ 39	2
Under 35	1

It may be fairly urged that while the above figures are representative of the degree of variation of plantation rubbers three years ago, they need not necessarily have any bearing on present conditions. It is no doubt the case that a gradual but marked improvement has been and is taking place, both in regard to absolute quality and degree of variation, but the evidence of manufacturers and others tendered to the Standardization Committee clearly shows that much still remains to be accomplished in this direction.

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* So far as we are at present able to ascertain it.

The data recorded below are selected from results obtained with samples received or purchased from various quarters during a comparatively recent period, and examined in the writer's laboratory according to the methods described in outline in the first part of this paper. The results may be taken as representing extremes of variability due to the various main factors, such as locality, soil, age, factory methods, etc. The figures given are based, in each case, on experimental results obtained with the " correct " or " perfect " cure of a standard mixing of the rubber in question.

The methods of testing and marking will be explained in detail in the paper to which reference has been made above ; but I may, perhaps, be permitted to say that they are substantially those accepted as sound and recommended for use in the proposed Testing Station by the Standardization Committee of the Rubber Growers' Association. The following general information will, I think, suffice for the purpose of the present communication.

RATE OF CURE.—The standard is 2 hours, which represents the time for the correct cure of a standard mixing cured on standard lines, time being the only variable.

1. TENSILES.—Standard 500 marks, based on breaking strain and elongation at break (work done on taking test piece to the break).

2. TYPE (GENERAL MECHANICAL PROPERTIES).—Standard 300 marks. Represents the chief inherent mechanical properties, such as capacity for work, elasticity, recovery, rate of increase of resistance to stretch.

3. CURING CAPACITY, PHYSICAL CONDITIONS AND STABILITY.—Standard 200 marks.

INDEX FIGURE OF QUALITY.—Standard 1,000 marks, made up by adding together marks allotted for 1, 2 and 3. The figures for Breaking Strain represent pounds per sq. inch, those for elongation the length of the test piece at the Break, taking the original length = 1.

No.	Nature of Rubber.	Rate of Cure (hours) (Standard 2 hours).	Breaking Strain. (lbs. per sq. inch.)	Elongation at Break. (Taking original length as = 1.)	Marks for Tensiles (Standard 500).	Marks for Type. (General Mechanical properties) (Standard 300)	Marks for Curing Capacity and Stability, etc. (Standard 200.)	Index Figure of Quality. (Standard 1,000.)
1	Smoked Sheet	1h. 50″	1,876	10.70	500	260	220	980
2	,,	2¾	1,700	10.00	425	300	140	865
3	,,	2	2,100	10·40	546	260	200	1,006
4	,,	2h. 5″	1,780	9·97	445	300	207	952
5	,,	2	1,420	10·60	375	140	200	715
6	,,	1¾	2,100	10·43	547	280	220	1,047
7	,	2	1,970	10·35	508	260	200	968
8		2½	2,250	10.75	605	340	160	1,105
9	,,	1½	1,478	9·86	383	260	240	883
10	,,	2¼	1,525	11·0	420	140	180	740
11	,,	2	2,190	10·40	570	240	200	1,010
12	,,	2¼	1,940	10·40	504	260	180	944
13	,,	1¾	1,960	10·9	533	140	220	893
14	,,	2¼	2,080	9·84	510	340	180	1,030
15	,,	2	1,600	10·67	430	140	200	770
16	,,	1¾	2,100	10·42	546	280	220	1,046
17	,,	1¾	2,290	10·80	618	340	220	1,178
18	,,	2	2,115	10·85	572	180	200	952
19	,,	2¼	2,530	10·55	666	260	180	1,106
20	,,	1½	1,700	10·30	438	220	240	903
21	Plain Sheet	2	1,600	10·60	420	180	200	800
22	,,	3½	1,250	10·11	320	180	80	580
23	,,	2½	2,100	10·60	556	340	160	1,056
24	,,	4½	1,950	10·68	520	300	0	820
25	,,	3	1,850	10·30	477	260	120	875

No.	Nature of Rubber.	Rate of Cure (hours) (Standard 2 hours).	Breaking Strain. (lbs. per sq. inch.)	Elongation at Break. (Taking original length as = 1.)	Marks for Tensiles (Standard 500).	Marks for Type. (General Mechanical properties) (Standard 300)	Marks for Curing Capacity and Stability, etc. (Standard 200.)	Index Figure of Quality. (Standard 1,000.)
26	Plain Sheet	2¾	1,912	10·76	514	260	140	914
27	,,	3¼	1,886	10·40	490	280	100	870
28	,,	2¼	1,875	10·00	470	300	180	950
29	,,	2	2,000	10·5	525	380	200	1,105
30	,,	4	2,450	11·00	674	380	40	1,094
31	,,	1	2,100	10·40	546	320	240	1,106
32	,,	2¼	1,872	10·50	492	260	180	932
33	,,	2¼	1,500	10·75	403	180	180	763
34	,,	1½	1,554	9·86	383	240	240	863
35	,,	3	1,315	9·80	322	220	120	662
36	,,	3½	1,700	10·06	430	260	80	770
37	,,	2	1,820	10·50	478	340	200	1,018
38	,,	1¼	2,340	10·5	610	280	240	1,130
39	,,	1¼	1,450	10·00	362	160	240	762
40	,,	1¾	1,900	10·40	494	320	220	1,034
41	Thin Pale Crepe	3¼	1,580	10·20	400	240	100	740
42	,,	4¼	1,500	11·36	425	140	20	585
43	,,	2¾	1,180	10·50	309	260	140	709
44	,,	3¼	1,400	10·60	372	180	100	650
45	,,	3	1735,	11·14	483	180	120	883
46	,,	3¾	2,000	11·50	525	300	60	885
47	,,	4	1,600	11·00	440	300	40	780
48	,,	3½	1,700	10·40	442	260	80	782
49	,,	3¼	1,850	10·50	484	320	100	904
50	,,	3	1,600	10·40	416	340	120	876

No.	Nature of Rubber.	Rate of Cure (hours) (Standard 2 hours).	Breaking Strain. (lbs. per sq. inch.)	Elongation at Break. (Taking original length as = 1.)	Marks for Tensiles (Standard 500).	Marks for Type. (General Mechanical properties) (Standard 300)	Marks for Curing Capacity and Stability, etc. (Standard 200.)	Index Figure of Quality. (Standard 1,000.)
51	Thin Medium to Dark Crepe	2¼	1,310	10·00	329	140	180	649
52	,,	2½	1,570	10·07	390	220	200	810
53	,,	2¾	1,405	10·22	359	180	140	679
54	,,	2¼	1,800	10·40	468	280	180	928
55	,,	3¼	1,500	10·50	394	300	100	794
56	Thick Pale Crepe	2½	2,100	10·60	557	240	160	957
57	,,	2½	2,060	10·54	542	260	160	962
58	,,	2½	1,640	10·56	434	240	160	834
59	,,	2¾	1,368	10·53	360	140	140	640
60	,,	2¾	1,650	10·20	421	240	140	944
61	,,	3¼	1,190	10·20	300	140	100	540
62	,,	Practically	uncurable.	Very under	cured at over	4 hours.		
63	Block	2¼	1,850	10·36	480	220	180	880
64	,,	1¼	1,786	10·03	340	340	240	1,033
65	,,	1¾	1,687	10·90	60	60	220	740
66	,,	1½	1,638	10·60	140	140	240	813
67	,,	2¼	1,552	9·65	260	260	180	822

The results obtained may be summarised as follows:

I.—SMOKED SHEET.

Number of Samples.	Range of Variation in Rate of Cure.	Variation in Breaking Strain. Highest. (lbs.)	Lowest. (lbs.)	Variation in Distensibility Highest.	Lowest.
20	1½ hrs. to 2½ hrs.	2,530	1,420	11·0	9·84

Variation in Marks for Tensile Properties Highest.	Lowest.	Variation in Marks for Type. (General Mechanical Properties) Highest.	Lowest.
666	375	340	140

Variation in Marks for Curing Capacity, etc. Highest.	Lowest.	Variation in Index Figures. Highest.	Lowest.
240	140	1,178	715

II.—PLAIN SHEET.

Number of Samples.	Range of Variation in Rate of Cure.	Variation in Breaking Strain. Highest. (lbs.)	Lowest. (lbs.)	Variation in Distensibility. Highest.	Lowest.
20	1 hr. to 4½ hrs.	2,450	1,315	11·0	9·80

Variation in Marks for Tensile Properties. Highest.	Lowest.	Variation in Marks for Type. (General Mechanical Properties) Highest.	Lowest.
674	320	380	180

Variation in Marks for Curing Capacity, etc. Highest.	Lowest.	Variation in Index Figure. Highest.	Lowest.
240	0	1,130	580

III.—Thin Crepes.

Number of Samples.	Range of Variation in Rate of Cure.	Variation in Breaking Strain.		Variation in Distensibility.	
		Highest. (lbs.)	Lowest. (lbs.)	Highest.	Lowest
15	2 hrs. to 4¼ hrs.	2,000	1,180	11·36	10·00

Variation in Marks for Tensile Properties.		Variation in Marks for Type. (General Mechanical Properties.)	
Highest.	Lowest.	Highest.	Lowest.
525	309	340	140

Variation in Marks for Curing Capacity, etc.		Variation in Index Figure.	
Highest.	Lowest.	Highest.	Lowest.
200	20	928	585

IV.—Thick (Pale) Crepes.

Number of Samples.	Range of Variation in Rate of Cure.	Variation in Breaking Strain.		Variation in Distensibility.	
		Highest. (lbs.)	Lowest. (lbs.)	Highest.	Lowest.
8	2½ hrs. to 4 hrs.	2,100	1,190	10·60	10·20

Variation in Marks for Tensile Properties.		Variation in Marks for Type. (General Mechanical Properties.)	
Highest.	Lowest.	Highest.	Lowest.
557	300	260	140

Variation in Marks for Curing Capacity, etc.		Variation in Index Figure.	
Highest.	Lowest.	Highest.	Lowest.
160	100	962	540

V.—BLOCK.

Number of Samples.	Range of Variation in Rate of Cure.	Variation in Breaking Strain. Highest. (lbs.)	Variation in Breaking Strain. Lowest. (lbs.)	Variation in Distensibility. Highest.	Variation in Distensibility. Lowest.
5	1¼ hrs. to 2¼ hrs.	1,850	1,550	10·90	9·85

Variation in Marks for Tensile Properties. Highest.	Variation in Marks for Tensile Properties. Lowest.	Variation in Marks for Type. (General Mechanical Properties.) Highest.	Variation in Marks for Type. (General Mechanical Properties.) Lowest.
480	382	340	60

Variation in Marks for Curing Capacity, etc. Highest.	Variation in Marks for Curing Capacity, etc. Lowest.	Variation in Index Figure. Highest.	Variation in Index Figure. Lowest.
240	180	1,033	740

VI.—ALL KINDS.

Number of Samples.	Rate of Cure. Shortest.	Rate of Cure. Longest.	Breaking Strain. (lbs. per sq. in.) Highest.	Breaking Strain. (lbs. per sq. in.) Lowest.	Distensibility. (original = 1) Highest.	Distensibility. (original = 1) Lowest.
67	1 hr.	4½ hrs.	2,530	1,180	11·36	9·80

Marks for Tensiles. Highest.	Marks for Tensiles. Lowest.	Marks for Type. Highest.	Marks for Type. Lowest.	Marks for Curing Capacity. Highest.	Marks for Curing Capacity. Lowest.
674	300	380	60	240	0

Index Figure. Highest.	Index Figure. Lowest.
1,178	540

The CHAIRMAN: I am sure we have all of us listened to this paper with very great interest, and I hope the discussion which will now follow it will be along the lines I have already indicated, of close consideration and attention to the main points of the paper itself. In order to get on with the discussion the more quickly I have arranged with Dr. Schidrowitz that at least part of the questions should be answered by him as they are put.

Mr. W. A. WILLIAMS: I was somewhat sorry that Dr. Schidrowitz did not give us any facts in respect to the preparing of samples, or refer particularly to the human element which comes in in the preparation of samples, and in milling. I think this has a very material effect upon the result. I do not know what the scheme is in respect to the preparation of samples, but I do not think it can be done on a time limit. You cannot say that every sample is to be milled for ten minutes or a quarter of an hour. It is a well-known fact that according to the properties of the rubber so its milling has to be varied in order to get the best results, and, unfortunately, we are still in that position where the human element has to come in to the extent that the operator's judgment has to be given as to when a sufficient amount of milling has been accomplished. I would be glad if Dr. Schidrowitz could give us some guidance as to the time of milling. The second question I wish to put is as to the effect upon the curve if the sample is over-milled. We know that we can mill to such an extent that vulcanisation might become an operation of extreme difficulty, and I should like to know what effect that has upon the curve.

Mr. P. J. Burgess : Can Dr. Schidrowitz give any general indication as to how the average results he has obtained from plantation rubber would compare with average results obtained from Fine Hard Para ?

Dr. Schidrowitz : Taking the better types of plantation rubbers and using them unwashed I found better results than I did with average washed samples, supplied by manufacturers, of Fine Hard Para. I may say this, that whereas we frequently got a general index figure for plantation rubber, unwashed, of well over 1,000, the average fine sample of washed Para comes rather lower, the figure in this case being something like 900.

Dr. Esch : I was not fully able to follow all that Dr. Schidrowitz had to say in his paper, but do not think he gives us figures concerning the measurements of the mixing rollers that he uses, or particulars of the temperature and the friction. If he will perhaps introduce these before the paper goes into print it will be of enormous interest. I have been through a lot of big American manufacturing plants, and know the very great difference in the methods of preliminary mechanical handling and mixing. I have had a lot of Mexican Guayule rubber brought before me in a liquid mass mixed with only 5 per cent. of sulphur, and given to vulcanisation for fifteen minutes only, at a temperature of 135 degrees Centigrade, and at these figures a wonderful sheet of vulcanised rubber was obtained which behaved quite differently from my samples of vulcanised Guayule. It seems that the preliminary handling of rubber mixings and the type of machinery used are very important matters. In American factories I have seen much bigger mills than anywhere else, and I have observed that the rotation velocity of American mills is an extremely high one, in comparison with the European mills. In America, the quantity of sulphur added is extremely low, especially in comparison with our German methods. I may have gone somewhat away from the matter immediately before us here, but I have done so in order to ascertain from Dr. Schidrowitz if he can give us his full particulars as to mechanical handling, especially as to friction and temperature if possible. I would like to know further if it is possible to give us the values for breaking strain and the like in decimal shape.

Dr. Schidrowitz: I would be able to, but as I have converted them all into the units we use in this country I do not see why I should work them all back again.

Dr. Esch : Could you give us a statement of the time that passed between the vulcanisation of the samples and the testing ? It would be interesting for certain reasons to know whether the testing was done instantly after vulcanisation or after some weeks.

Dr. Schidrowitz: I have not given full details; I said distinctly that I proposed to publish them later. The question as to the size of the rollers and so on does not matter. This is a scheme for testing rubbers themselves under standard conditions, and the conditions have been kept the same. I have compared the mixings made in the factory with mixings of the same rubber made in my laboratory, and we have got practically identical results; so very close indeed as to make no practical difference whatever. If this scheme is to be applied it must be under standard conditions, much as any manufacturer carries out his work under standard conditions. The same principle has been applied to the time between mixing and curing on the one hand, and on the other to the time between curing and testing. Mr. Williams has asked a question as to the effect of overworking the rubber. In overworking within reasonable limits, not working the rubber in such a way as to reduce it to a jelly, but giving it an extra half-hour or quarter of an hour on the mill, it has been found that rate of cure, but not type, is affected. Of course, it also may affect the best tensile results you can get, because naturally by breaking down you affect the rubber generally, but curiously enough you do not affect the type of the curve. As to the degree or time of milling, I may say that all the mixings have been carried out by one and the same mixer under identical condition with the object in every case of getting the best results, and we have from time to time repeated them and got results so close that the differences are not worth talking about. We have also compared mixings made in the laboratory with mixings made in the works in several cases, and there again we have had results that do not vary appreciably. I have reason to believe, however, that one can to a very large extent get over the difficulty of the human element in mixing by using one of the new type of mechanical mixers which eliminates the handling of the rubber. In large testing stations this would be very valuable, because it would eliminate the difference due to actual handling as between one man and another.

Mr. Burgess: A point arises out of this last statement. You say the overworking does not alter the type of the curve, but lengthens the time of cure. I gather from this that the correct rate of cure can be indicated with equal accuracy from the overworked sample as from a sample which has only been subjected to normal work?

Dr. Schidrowitz: Yes. If you had a correspondingly slower preliminary cure you would be able from that to judge your perfect cure.

Dr. D. J. Thompson: There are one or two questions I would like to ask Dr. Schidrowitz if it is in order to talk upon the application of these matters to standardisation. One is as to the type of mix, because this has a very great influence. Taking different mixings, some with just rubber and sulphur, other with some accelerators, and making your tests not with a Schopper machine, but just in an ordinary way, we would find the sequence to be entirely different. If in standardisation we take just the one type, the manufacturer can apply it only to one type. Then another question is as to the perfect cure. I believe Dr. Schidrowitz has been working on this for a very long time, but I should like to know just how long it is since he decided what type of curve gave a perfect cure, because the same compound is used in many cases for different purposes and a different cure is given for different purposes. In some cases we have to get it a little over or a little under, and I would like to know in what way that perfect cure is to apply. Then, furthermore, I am not doubting that variability is there, but most manufacturers have, I believe, now got arrangements by which they steady that variability by adding other things to the rubber. Speaking for ourselves, the variability is there with certain mixes, but if you can add steadying agents you get fairly uniform results—just as uniform as if you bought on that standardisation and chanced matters by putting in another mix of a different type. In any case the large manufacturers will test all the rubber before using it, and not accept any standardisation from one mix.

The CHAIRMAN: All matters of this kind are really a side question. This one type of mix has been adopted simply to bring different rubbers in comparison. The question as to the results rubbers give when subjected to certain treatment in a certain standard mix, that is fixed once for all.

Dr. SCHIDROWITZ: I do not think the exact significance of this matter is really appreciated. "Ordinary tests" are no use whatever, and the fact is that these "ordinary tests" have done more harm in the past than good. When I made them I got my results all over the place, just as, apparently, Dr. Thompson is getting his results now. The crux of the scheme is that the manufacturer who has used a certain type of rubber for a certain mix goes into the market and wants to buy it again. Dr. Thompson says not? Well, other manufacturers get repeat orders, and they do; and if you give them a rubber which shows identically the same rate of cure and so forth, you put them in a position to buy what they require. I am not going to discuss the whole question of variability any more. Those who wish to know what the majority of manufacturers do think may do well to study the report of the standardisation committee of the Rubber Growers' Association. I have been asked whether the perfect cure is under-cured or over-cured. It is neither. For comparative purposes you must obviously always make the best cure obtainable.

The CHAIRMAN: What temperature was selected for the purpose? Suppose you adopted another temperature, would you get a series of curves similar to those obtained at the first temperature?

Mr. W. A. WILLIAMS: I should rather like to know how many tests are carried out to determine a curve for a particular rubber. The author has laid great emphasis on the accuracy of the mixing conditions, the mixing and the curing. It is very important in getting a curve like that to have a considerable number of experiments.

Dr. SCHIDROWITZ: In one case we made twenty or thirty cures from the same mixing. If an experiment is inaccurate it is shown at once by the type of the curve. In the ordinary way I make a preliminary cure, and from this I judge the type of the curve and also the position where the perfect cure for that type should come. From these data the perfect cure is put on, and if this comes right, and if the type of the curve is the same as in the preliminary cure, there can so far as I can, judge, be no experimental error. Further experiments, therefore, are unnecessary. If this point of view can be criticised I shall be glad to hear the criticism, but if not I maintain that it is better to have one result which must be mathematically correct than to take an average of a number of errors, as is the case with most of the methods in the past.

Dr. ESCH: Dr. Schidrowitz mentioned that to overcome the influence of human handling of the mixings it would be a good thing to use one of the new type of mechanical mixers. Does he use those of the type employed for making breadstuffs? I have found that machinery of that type in Germany gives awful results. This kind of machine needs no workman's help during the time of mixing, but it gets away a lot of the mixing through the bearings, so that one loses the most valuable constituents.

Dr. SCHIDROWITZ: I am referring to a type of machine that has given satisfaction in several works where it has been in use for several years past. I may say, without referring to the particular manufacturers or to the type of machine, that it has been under my eye in some big cable works. I have seen it at work there and elsewhere. I quite agree with Dr. Esch that in the early days at any rate, the pitch of the blades and so on was such that you did not get the results you wanted. Excellent results are, however, obtained from the machine that I have in mind.

Dr. ESCH: Was it the type of machinery I have seen working on the screwing type, two screws working together? I have found that this type needs nearly double the time for mixing that is occupied in the ordinary rolling.

Dr. SCHIDROWITZ: I have seen most difficult mixings made, I think in about forty minutes, as against an hour to an hour and five minutes in an ordinary mill. That was a machine taking a charge of 70 to 80 lbs. But I think we are rather wandering.

The CHAIRMAN: Yes, let us keep to the point.

Dr. SCHIDROWITZ: I do not think I have anything further to add. I have covered all the ground, I imagine.

Some American Methods of Testing Mechanical Rubber Goods.

By **D. E. DOUTY,**
General Manager, United States Conditioning and Testing Company,
New York City.

One of the greatest benefits to be secured through conferences of this kind is the interchange of ideas and the casting, as it were, into a common receptacle, of the small bits of knowledge which we may each possess, to the end that each one may draw from the collection such portions as are useful for his particular purpose. It is very helpful to any person interested in the pursuit of a growing subject to receive from others wholesome, constructive criticism of his ideas. With this purpose in mind, I have prepared a brief outline of some of the methods being used in American laboratories for the determination of the physical properties of vulcanized rubber. There may not be a large amount of material in what I shall present that is new, or that is different from current English practice, and being somewhat unfamiliar with English methods, I may possibly describe methods already familiar to you.

Until quite recently, American engineers and purchasing officers have based their tests and specifications upon the chemical characteristics of the vulcanized rubber. The difficulty of interpreting these tests in terms of actual service has gradually awakened a feeling that physical tests based upon characteristics which are known to influence and limit the length and efficiency of the service that the material will perform, would form more useful criteria upon which to judge the quality of the material than chemical tests. As soon as this feeling began to gain strength, the need of some recognized standard methods for testing the service characteristics became evident.

For a material as variable as rubber it is more essential that we should have uniform methods than that we should seek extreme accuracy and refinement of measurements. Manufacturers are usually the ones who suffer most by the existence of a large number of testing methods which are based upon the same general principles, but yield different results. They also suffer in their competitive business when called upon to manufacture the same line of goods to a variety of specifications.

In 1906, the National Bureau of Standards of the United States Government became interested in assisting the various Government Departments in formulating specifications for their rubber supplies. At that time I had the honor to be a member of the Bureau's Scientific Staff and was assigned the mechanical portion of the subject as a part of the engineering work. The plan pursued in developing the subject was characteristic of the general policy of the Bureau of Standards in such work. A careful study was made of all specifications and methods of testing which could be obtained. The fundamental principles of manufacture were considered, and as much information as possible was collected upon the service conditions of the various materials. Conferences with the Government Departments, manufacturers, technical experts and committees of scientific societies have served to develop some degree of uniformity. This work had progressed sufficiently at the time of the International Rubber Exhibition in New York, September, 1912, so that an outline was presented to the conference by Mr. P. L. Wormeley, and a Circular of Information, No. 38 of the Bureau of Standards, entitled "The Testing of Mechanical Rubber Goods," was distributed. The demands for this circular were so great that the first edition was soon exhausted, and in April, 1913, a second revised edition was published. The Bureau of Standards also exhibited, through the courtesy of the Exposition, some pieces of testing apparatus which proved very interesting to the patrons and attracted considerable attention. Coincident with this work on the physical characteristics of vulcanized rubber, conferences and committees of chemists have been striving to unify and develop the methods of Chemical Analysis.

From a conference representing very wide interests a committee now known as the Joint Rubber Insulation Committee was established. It consists of three railroad men, three representatives of manufacturers and three independent chemists. Of these nine members, seven are chemists and two are engineers. This committee has limited its activities thus far to the development of specifications and an analytical procedure for compounds of the 30% Para type. A very excellent and helpful preliminary report has been prepared by the Bureau of Standards as a supplement to Bureau Circular No. 38. The time, however, does not permit me to discuss the chemical phase of rubber testing, and I shall, therefore, limit myself to a brief outline of the methods of physical tests described in the original Bureau of Standards Circular No. 38.

The tests to be described are—tensile strength or tension, ultimate elongation, elasticity or permanent set, reduction in tension or reaction when stretched to a definite elongation, and "friction" in ply goods like hose, packing, etc. The apparatus described and illustrated was either designed or adapted by Mr. P. L. Wormeley, engineer in charge of the testing of miscellaneous materials at the Bureau of Standards. The various pieces were designed to meet three requirements, viz., simplicity of construction to secure moderate cost, accuracy of measurement within the limits of variation of the material, and speed and simplicity of operation.

SAMPLES.

The preparation of rubber test samples requires more careful attention than most materials. The least imperfections in the edge or surface of the test specimen may cause very great changes in the result. Its shape and size will also influence the results.

After very careful consideration the straight dumb-bell shaped specimen has been adopted and is in almost universal use in America. It consists of a strip with parallel sides for a length usually of 2 inches expanding at the ends to about three times the width of the parallel-sided portion. The width of the parallel-sided portion is one-quarter or one-half inch, depending on the size of the sample from which it is taken. The specimen is cut with a die which is either struck with a mallet or forced through the material by some kind of press. The Bureau of

Standards uses a small sized arbor press fitted with a spherical seated base upon which a sheet of heavy leather is mounted as a firm but slightly yielding surface. By means of the spherical seated base the surface of the material is brought parallel with the cutting edge of the die and perpendicular to its direction of movement. This ensures specimens whose cross sections are accurately rectangular. The die is made of the best tool steel; and great care is exercised to keep it with a very fine, sharp cutting edge. The arbor press fitted with a die is shown in Fig. 1. A ¼ inch test specimen is attached to a block at the right of the press. The width of the specimen being accurately determined by the width of the die, the thickness must be determined in order to compute the values for tensile strength in terms of the area of cross section. It is therefore necessary to secure uniformity of thickness. Where the specimen is cut from a calendered sheet no further preparation is necessary. When, however, the specimen is cut from material which has been frictioned to canvas insertion or to a woven cover, it is necessary to remove the layer of frictioning composition and the surface indentations before an accurate measurement can be made of the thickness.

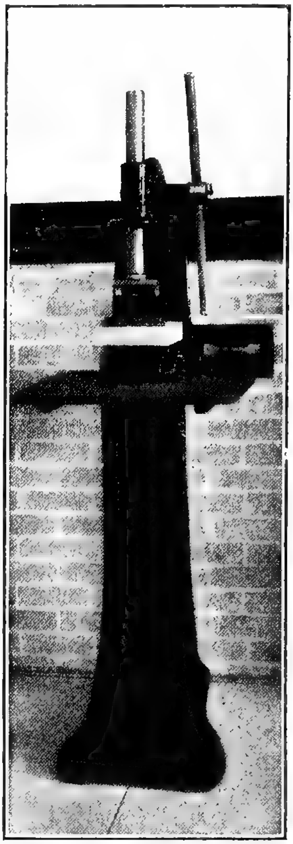

FIG. 1.—ARBOR PRESS FITTED WITH DIE FOR CUTTING TEST PIECES. TEST PIECE SHOWN ON RIGHT.

BUFFING WHEEL FOR RUBBER.

The backing which is used to cement the lining to the fabric, if not removed, affects to a greater or less extent the values obtained for tensile strength and recovery. The more usual method is to remove the backing by means of an emery wheel, and the operation as commonly performed requires considerable care and skill to prevent injury to the rubber. The buffing wheel shown in the accompanying illustration, Fig. 2, has been especially designed at the Bureau of Standards for the purpose of buffing rubber and is giving excellent results. The wheel is operated by a ⅛ horse power motor. The rubber to be buffed is clamped as shown, to a carriage which is moved back and forth under the 5 inch by 1 inch emery wheel (No. 60) running at about 3,000 revolutions per minute. The central portion of the carriage just under the rubber slightly raised, by which means it has been found that the operation is more easily performed, and with less danger of injury to the rubber. The thumb screw marked "A" serves to lower the wheel by very small amounts as the buffing proceeds. The shields marked "B" are for the purpose of keeping the fine particles of rubber off the guide. The starting box, though not necessary, is desirable in bringing the wheel gradually up to full speed.

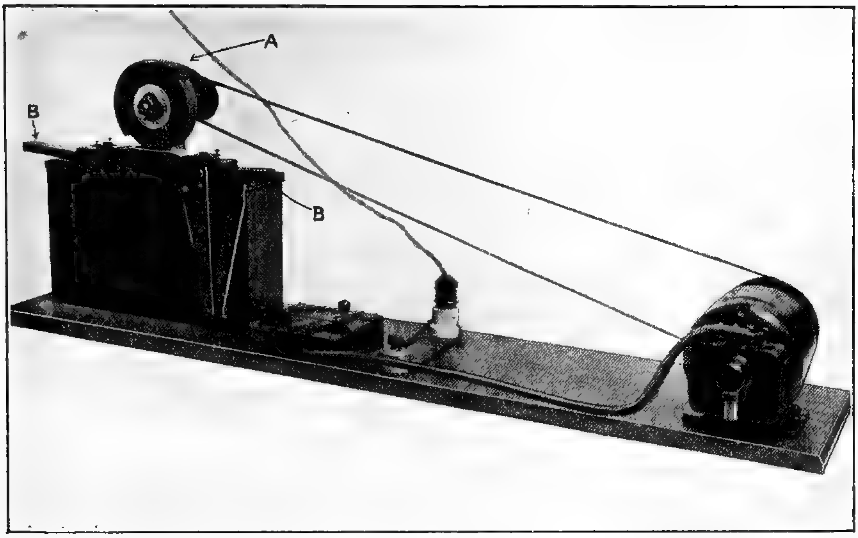

FIG. 2.—MACHINE FOR SURFACING TEST SPECIMENS. REMOVING FRICTION FROM FIRE HOSE, ETC.

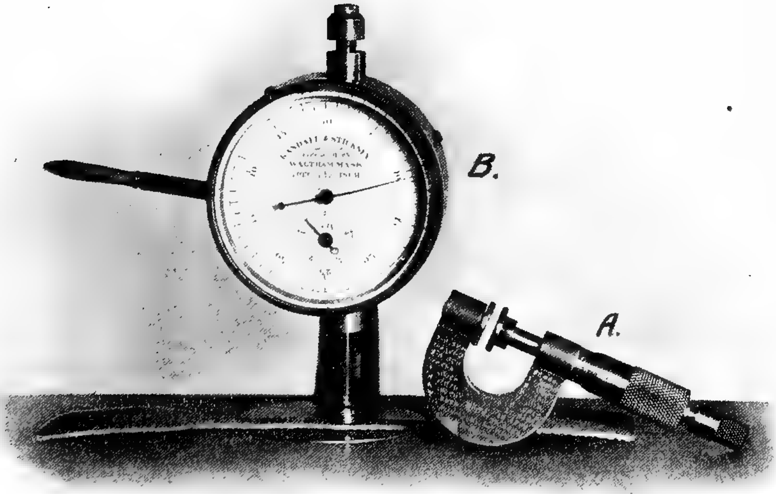

FIG. 3.—THICKNESS GAUGES.

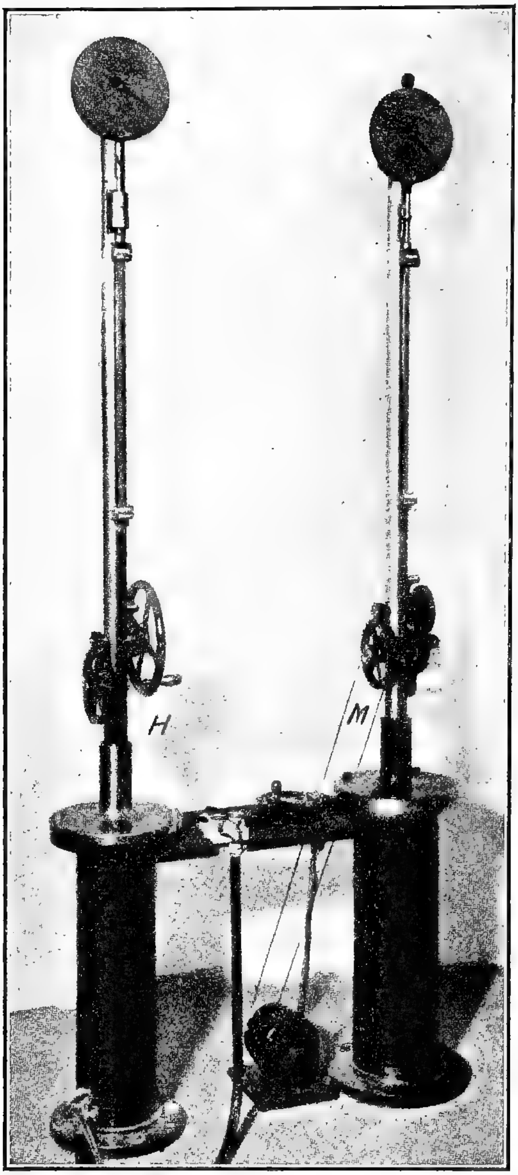

FIG. 4.—TWO MACHINES FOR DETERMINING THE TENSILE STRENGTH OF RUBBER.

H.—Hand Driven.

M.—Motor Driven.

For details see Figs. 5 and 6.

MICROMETER.

The thickness is measured by a micrometer which is especially designed to subject the material to a small uniform pressure. Two forms of micrometer are shown in Fig. 3. A test piece of the shape shown in Fig. 1 has been criticised by some who complain of the large number of grip breaks they obtain and the frequency with which the breaks occur outside of the parallel portion. This difficulty is caused by the shape of the specimen where it expands from the parallel portion to the gripped portion. This portion might be called the fillet. If the radius of curvature of this fillet is too short, the specimen is liable to break in the fillet, not as a true tension break but by tearing. The curvature must be such that the lines of stress from the parallel portion to any part of the gripped portion lay entirely inside the specimen. If the lines of stress along the extreme fibres pass outside the specimen the break will often occur in the curved portion. After considerable experimentation a form has been developed which is practically free from clip breaks. In five years' experience, during which many thousand test have been made, the only clip breaks which have occurred were directly traceable to mineral particles or air holes.

THE GAUGED LENGTH.

In all tests where the extension of the test specimen is to be measured it is necessary to have a definite gauged length. This is usually 2 inches, and is marked by means of a stamp consisting of two parallel steel blades set accurately 2 inches apart. This is used with an ordinary rubber stamp pad and makes two very sharp clean lines without the possibilities of errors of measurement.

TENSION TESTS.

For tension tests, a special form of testing machine (Fig. 4) with several distinctive features has been designed and developed by Mr. Wormeley. It is constructed largely from stock materials, and can be built at low cost in almost any shop. The base consists of a piece of standard 7-inch steel pipe fitted with standard flanges. To the top flange is bolted a standard reducing flange 7 inches by 2 inches. A piece of 2-inch cold rolled shafting forms the pedestal of the machine. It passes through the reducing flange and carries at its upper end a dynamometer of any desired capacity. One grip is attached to the dynamometer by a double hinged joint so as to have freedom in both directions, and the other is bolted rigidly to a rack fitted into a way milled in the shaft and driven by a pinion and gear train (Fig. 5) at the lower end. The machine can be either hand or motor driven, and the mechanism works so easily that the lower grip can be quickly returned to its upper position after a test. Fig. 4a shows a machine of this type being constructed in the instrument shop of the United States Conditioning and Testing Company for use in testing rubber, yarn and fabrics. Interchangeable grips make it available for all kinds of tensile tests, and a series of dynamometers of 30 lbs., 150 lbs. and 300 lbs. capacity, interchangeable, increase its range and vary its sensibility.

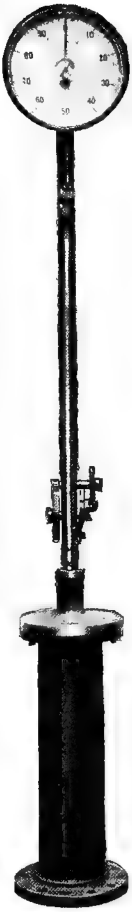

FIG. 4A.

There are two parts which may have special interest: the grips, and the device for preventing the recoil of the balance at the time the specimen breaks. The grips are clamps of which the pressure portion consists of a series of eccentrically drilled discs, with knurled edges, so mounted as to automatically tighten as the tension increases. The discs work independently, but by means of a small piece of rod passing through them and fitting loosely, are operated together in placing or removing the specimen. This form of grip shown in Fig. 6 has proved to be convenient, rapid and very efficient. There is no cutting or tearing action; no set screws to tighten at the beginning or during the test, and the grip is very easily opened after the specimen has broken. Any inequalities in the thickness of the specimen are provided for by the segmented form of the pressure roller. A series of tests made upon uniform and non-uniform samples shows that at all times the stress lines are straight, and that pure tension without tearing action is obtained.

The recoil of the spring balance at the time of the break is prevented by a toothless rack, very positive in its action and simple in construction. There is no back lash nor lost motion. A steel plate marked " A " in Fig. 6 fits loosely on the rod " B " to which the upper grip is attached, and rests upon lugs shown on the rod at " C." The other end is drilled to take with an easy sliding fit the rod " D," not visible in the figure, countersunk into the shaft of the machine. As tension is applied to the test specimen, the upper grip moves downward, and the steel plate follows freely, offering no resistance to the motion. The upper edge of the plate is in continuous contact with the front side of the rod " D," and the lower edge is in contact with the back of " D." As soon as the grip begins to return the bar seizes the rod " D " and holds the grip in its lowest position. It is only necessary to release the tension upon the grip by hand, place a finger under the overhanging end, and support it while it slides smoothly up the rod. This device removes entirely one

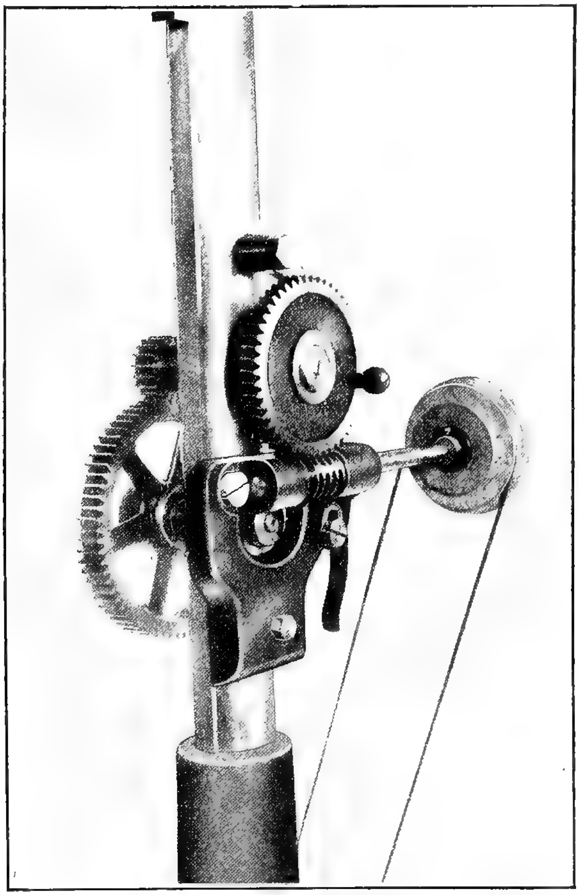

FIG. 5.—DRIVING GEAR FOR TESTING MACHINE.

of the greatest objections which have been made to the spring dynamometer as a means of measuring force in tension tests. It effectively prevents the injury of the balance by the recoil, and at the same time offers no resistance whatever to the free action of the instrument. By fitting the dynamometer with a single needle designed to stand at the maximum reading it becomes equivalent to a freely suspended helical spring the extension of which within its elastic limit is directly proportional to the force. Changes due to temperature, corrosion, ageing, etc., can be immediately detected by simply checking its readings at a few definite points by direct calebration with standard weights. This can be done easily in a few minutes before beginning the tests. As a matter of fact, the uncertainty in the reading of a well-made dynamometer is very much less than in any type of beam and lever device, whether of the balance beam or pendulum form. The ultimate elongation is determined by means of a graduated scale mounted on the

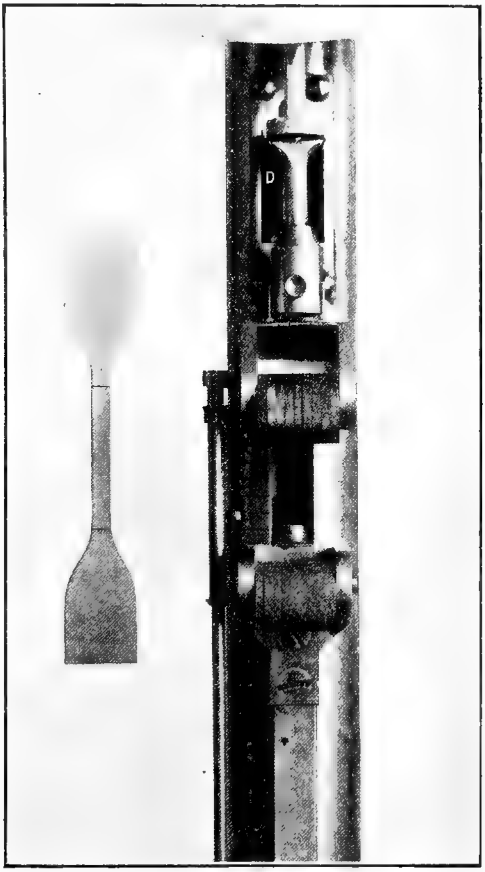

Fig. 6.

side of the column. As the tension is increased a pointer is made to follow the upper mark on the specimen, and another pointer follows the lower mark. The elongation at breaking can be read at once from the scale.

Elasticity Test.

The apparatus for the testing of the elasticity, or better, the permanent set after a specimen has been subjected to a definite amount of elongation, consists of six sets of clamps mounted on a horizontal base, Fig. 7. One-half of the clamps are fastened rigidly to the end of the base, the other half are attached to straps which pass through a clamp and are attached to spools which may engage separately a rod upon which they are mounted. By turning these spools the specimen can be stretched to any degree desired, clamped at that position for the definite time, then released, and after the lapse of ten seconds quickly measured. The amount of permanent set is expressed in percentage of the gaged length.

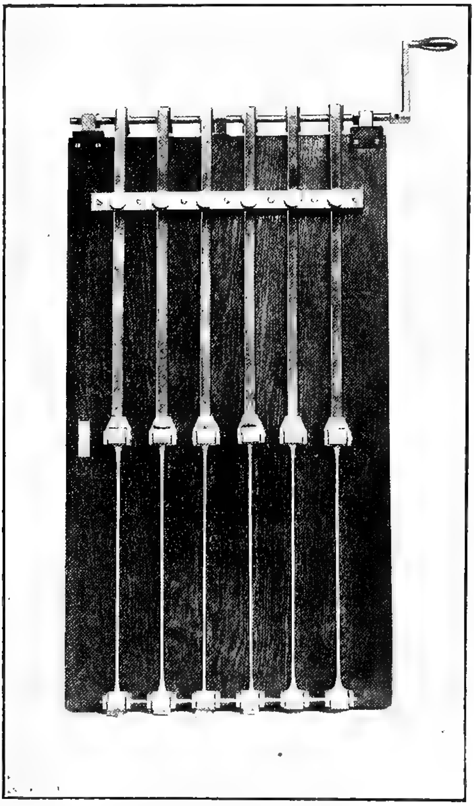

Fig. 7.—Apparatus for determining permanent set 6 specimens.

Decrease in Tension.

This test is similar to the elasticity test. Instead of the permanent set for a definite percentage of elongation, the decrease in reaction of the rubber under definite elongation is determined. One clamp is attached to a dynamometer (Fig. 8) and the other to a mechanism similar to that for elasticity. The specimens are stretched a definite amount, clamped and allowed to stand under the tension of a dynamometer. After a given time the decrease in the dynamometer reading is read, and the value forms an indication of the value of the sample.

TESTING RUBBER BANDS.

The United States Government purchases a large quantity of rubber bands upon a single contract made at the beginning of each fiscal year by soliciting competitive bids accompanied by samples of the various sizes. In order to determine the quality of these samples for comparison of prices and the subsequent deliveries, to know if they are equal to the samples accepted, they are tested for strength and elongation.

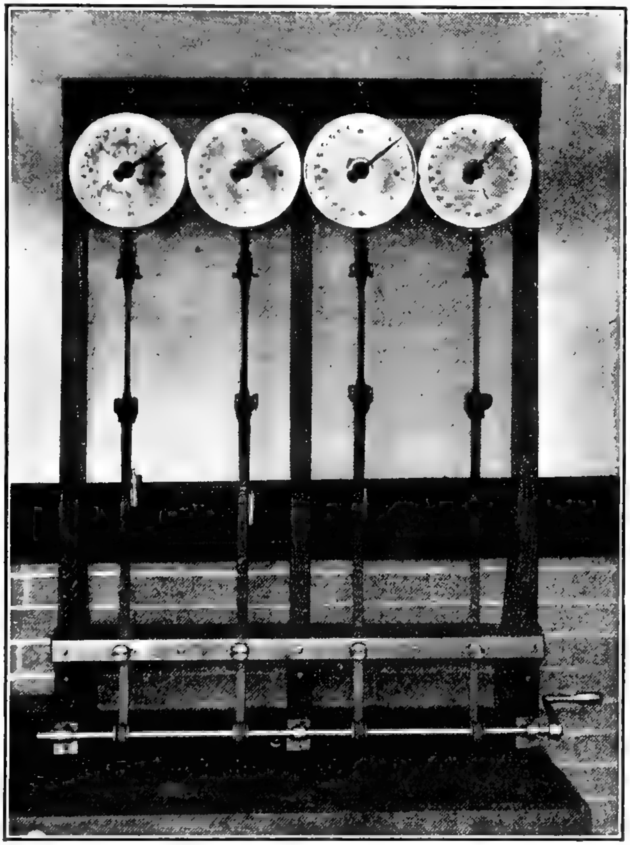

FIG. 8.—TENSION APPARATUS.

Fig. 9 shows a motor-driven machine of 15 pounds capacity designed for testing rubber bands. The load is applied through the steel tape 1, at the end of which is the grip 2. The graduated steel tape 3,attached to grip 2, with its zero point coinciding with the centre of the spool 4, passes up behind the test specimen and through the column 5 to a reel just behind the spring balance. When the specimen breaks, its elongation is determined by the distance between the centres of spools as shown by the tape 3. The plate 6 holds the springs under the maximum tension in a way already explained in connection with Fig 4. This machine is also provided with eccentric grips which are used for testing straight specimens of low tensile strength. It is also made with motor drive.

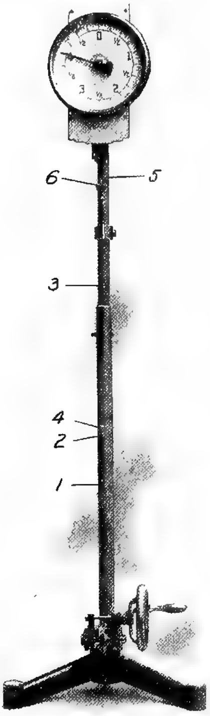

Fig. 9.—Machine for testing Rubber Bands.

Friction Test.

The "friction" or adhesion between the plies of canvas on rubber hose and between the canvas and the rubber tube and cover is of great importance; in fact, the life of hose depends in great measure upon the efficiency of this adhesion. The same is true and to an even greater extent in the case of rubber belting. The friction of "plied" hose is determined in the following manner (Fig. 10): In preparing test pieces, a short length of hose is pressed tightly over a slightly tapered mandrel, such as the ones shown. The mandrel is put in a lathe, and 1-inch rings are cut with a pointed knife. Beginning at the lap a short length of canvas is separated and the ring is pressed snugly over a mandrel which is free to revolve in roller bearings. The rate at which the canvas strips under the action of a specified weight suspended from its detached end is taken as a measure of the friction. A marked difference is often found in the friction between different plies of the same hose, as well as at different points along the same ply. Uniformity in the friction is desirable. The results of this test are influenced by the temperature conditions, the rate of stripping caused by a given weight being greater at high than at low temperatures. Also, the rate of stripping is greater if the mandrel fits snugly in the ring than if the ring is allowed to sag over a loose mandrel. The variation in friction, however, in the same hose is often such as to obscure these influences unless observations are made under conditions which differ greatly.

In connection with this test, attention may be called to a point which, though generally recognized, is sometimes lost sight of in the interpretation of results. It has been observed that no stripping is produced by increasing the weight up to a certain point, after which the rate of stripping increases gradually at first, and then more rapidly, with small increments in weight, until finally a very small increase in weight causes a large change in the rate of stripping. The general behavior is illustrated graphically in Fig. 11, in which each point represents the average of a number of tests on a very uniformly frictioned hose.

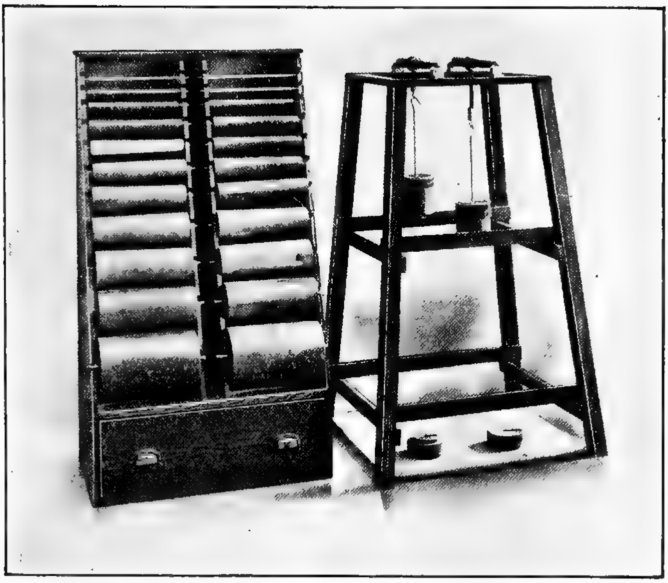

FIG. 10.—APPARATUS FOR TESTING " FRICTION " OF RUBBER HOSE.

As a result of this behavior, an air hose, for example, which is required to show a rate of stripping not exceeding 6 inches in 10 minutes under 25 pounds, might be regarded as of very inferior quality if it stripped say, 20 inches in 10 minutes, whereas the same hose would probably show little or no stripping under 20 pounds, and come within the required limit under 22 pounds.

The " friction " of rubber-lined fire hose is usually determined as follows : A 1-inch strip is cut and a portion of the tube separated from the jacket. The detached end of the jacket is clamped in a stationary

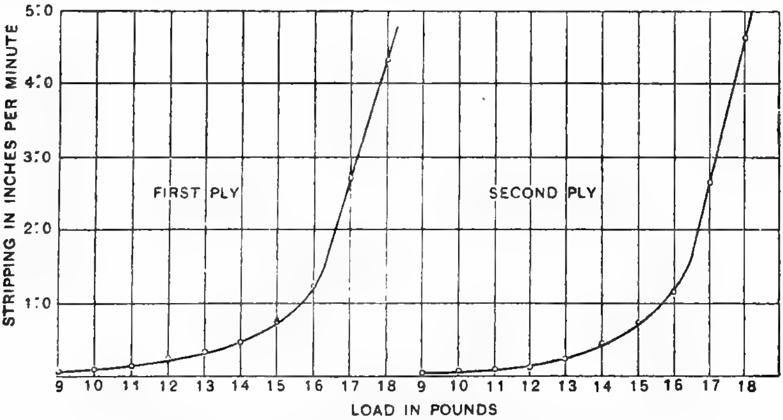

FIG. 11.—" FRICTION " TEST OF RUBBER.
CURVES SHOWING RATE OF STRIPPING UNDER DIFFERENT LOADS.

grip and the weight is suspended from the rubber tube. The " friction " between the plies of duck in rubber belting is sometimes measured in the same way (Fig. 12, B), but some prefer to apply the load in a direction at right angles to the plane of separation, as in the case of " plied " hose. This is done by cutting the belt about halfway through along parallel lines 1 inch apart. The belt rests on horizontal supports just outside of the strip which has been cut, and the weight is suspended from the detached end of the duck (Fig. 12, A). It is found that for a given weight the rate of stripping is decidedly greater by the former method than by the latter.

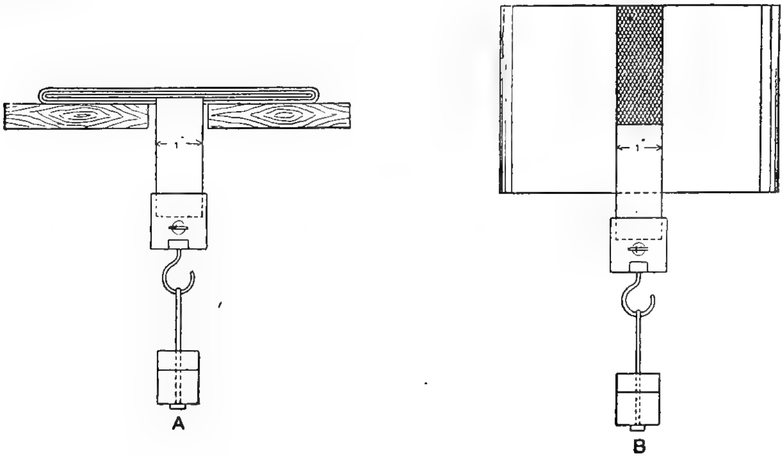

FIG. 12.—TWO METHODS OF TESTING THE " FRICTION " OF RUBBER BELTING.

INTERPRETATION OF TESTS.

The most important part of testing is the interpretation of the tests and the assignment of the properties measured to proper relative position in order of importance. Tests which cannot be interpreted in terms of the service the material will render have very little value. In developing a system of testing, it therefore becomes necessary to study carefully the meaning of every proposed test. This very often requires

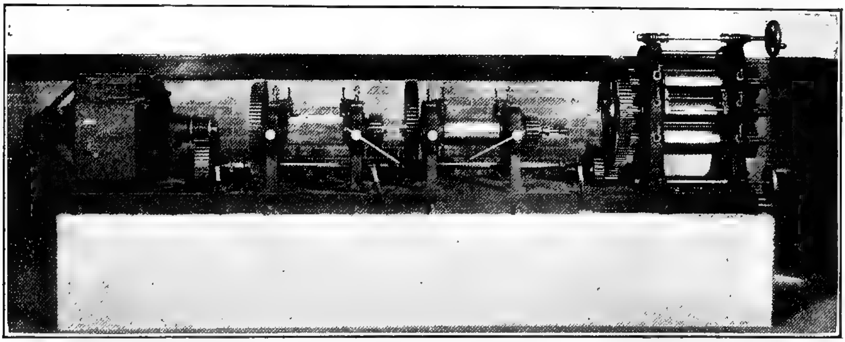

FIG. 13.—MACHINE FOR MAKING EXPERIMENTAL SHEET.

an investigation of the raw material, methods of preparation and the proportions in various combinations.

The U.S. Bureau of Standards is following in its rubber testing the broad general policy which it has adopted in its work on the preparations of specifications and methods of testing of materials. The rubber laboratory has been equipped with a complete installation of apparatus for the manufacture of sheet rubber. Fig. 13 shows the motor driven direct connected washer, mixer and calender, upon which sheets 12 inches wide can be made. With this equipment it is possible to make experimental sheets of any composition under more accurate control than exists in commercial operation and study the effect of varying one element at a time. It is hoped in this way to obtain information which will be of value, not only in the preparation of specifications and tests, but to the manufacturer in the control and production of his goods.

The Chairman: One great difficulty with a test piece of the description that has to be cut by a die is that unless the most scrupulous care is taken in keeping the edge of the die not only sharp but extremely smooth the results of the tests will vary to an extent that no one will believe who has not experienced it.

Mr. P. J. Burgess: Dr. Schidrowitz this morning drew attention to the necessity for extremely accurate temperature registration in vulcanizing. I do not know whether you have found the same necessity for extreme accuracy in registering temperatures.

Professor K. Memmler: Perhaps I may be allowed to give some information with regard to a number of tests which were recently made, and which I think will be helpful in connection with the consideration of this important paper. A lot of tests were made with rod shaped pieces in addition to ring shaped pieces, and it was found that in some cases the heads gave way, and in others they did not do so. It was found that if you were using a rod shaped test piece you must standardize it rigidly. There are peculiarities in connection with rod shaped test pieces. The method of elongation is difficult. It is difficult to feel the marks of test piece elongation because they broaden out. Another disagreeable feature of rod shaped test pieces is that of clamping. We also tried to use eccentric clipped clamps. When I visited the Bureau of Standards in America in 1912 I saw the particular method of clamping which is described in the paper, and have since tried to use it in our own laboratory. We tried experiments with different eccentrics and with different numbers of eccentric discs. We found that with the low grade rubbers this eccentric form of clamping acted very well, but directly you were dealing with high grade material it did not work. I would be glad to know if you have made similar observations. In spite of what I have already said, there are undoubtedly many advantages in the rod shaped test body. One of the objections to the ring shaped test piece with no salt (?) is that one has to stick to a standard ring, but in the latest methods of cutting by means of rotatory knives and so on this is not necessary, and all kinds of rings can be examined. My opinion is that the most important problem of testing soft rubbers is that of evaluation of the crude rubber. Our experience is that there is not any very great demand for the examination of finished goods. I noticed that in the Bureau of Standards in America the tests were mainly on finished goods and not on the raw material. I should be obliged to Mr. Douty if he can tell us if they have overcome the difficulties of clamping very soft rubbers such as we would use in testing the raw material?

Dr. F. ARNDT: I would like to know whether a standard mixture was used for the tests in America, and if so, what was its composition. It would also be interesting to know the age of the test pieces, as the tearing strain depends on the length of time since the test.

Mr. DOUTY: I will answer the last gentleman's question first. He probably was not in at the time I started the paper. In our work we have not reached the stage of attempting to standardize crude rubber. We are interested in assisting the railroads, the users of rubber, so that these tests we have here are particularly designed to apply to rubber that has been through the later processes. The Bureau of Standards ultimately intends to take up the question of standardization. Unfortunately, I have not been connected with the Bureau during the last eighteen months, and I do not know what progress has been made. This machine was ordered just before I left. The most critical thing in America at the present time is to assist the users of rubber, because as soon as we assist the users of rubber we will assist the manufacturers. At the time I undertook the work we had in our Government nine large executive departments, of which five purchased rubber goods quite extensively. There were, however, about a dozen different specifications for the same thing. We now get them to fix their year's contracts so that the manufacturers can give their quotations on large quantities. We adopt quite a different method in dealing with the rubber problem from the one that you people in this country follow. You started with the crude rubber and you are coming down and assisting your manufacturers from that standpoint. We are starting with the user and working the other way. But I am rather digressing. I am very glad that in connection with the testing question emphasis was laid on the necessity for extreme accuracy of the cutting edge. Our dies could be used to shave your face, and you would find them more comfortable than the best safety blade on the market. They are clamped against a pad through which the edge cannot be injured. We find that where we have a faulty specimen it is generally a little particle of mineral matter or an air bubble that causes it. Our investigations upon crude rubber and vulcanization have not progressed sufficiently to give any very definite temperature, but that temperature must be very accurately regulated is certain. Mr. Wormeley's paper, which will be presented to-morrow, on the influence of temperature on physical tests will give the results of some preliminary tests in this connection. They show certainly the necessity for testing your rubber at a definite temperature.

Mr. W. T. GIBSON: I believe our American friends are able to say something about the usefulness of the revolving ring for the purpose of making tensile tests. Mr. Wormeley has made some remarks in a communication on this matter, and perhaps Mr. Douty will be able to supplement those remarks.

Mr. DOUTY: I abstained from the discussion of the ring form because it is a subject that lends itself to quite extensive discussion, and I do not want to take up the time of the Congress. I would say there is a fairly complete discussion of the elongation and values of tensile strength in Pamphlet No. 38 of the Bureau of Standards. I do not think we should take the time of the Congress to discuss that. Professor Memmler and myself have had a number of suggestive conferences with regard to the matter. In our work we found the values for the elongation by the ring method were only about 85 hundredths of the value we found by the straight system.

Dr. SCHIDROWITZ : I made some parallel experiments, using a rather thinner form of ring. The thinner the ring used the less the difference between the outside and the inside tension. I made the tests with a ring about 2·5 millimetres inside to 5 millimetres outside. I worked for a very direct pull and found that the difference was slight.

Dr. STEVENS : I think Dr. Memmler, in an original communication, published some figures showing the results of experiments which he had made with rings that were thinner than others. I think he showed that he had got higher results with thin rings than with thick ones.

Dr. SCHIDROWITZ : There is no question that if you are going to test systematically for a specific purpose you always have to take a test piece, using a rod or anything else, of about the same thickness.

The Influence of Temperature on the Tensile Properties of Rubber Compounds.

BY

P. L. WORMELEY.

(United States Bureau of Standards).

The CHAIRMAN : The first paper this afternoon is that by Mr. P. L. Wormeley, of the United States Bureau of Standards, on the Influence of Temperature on the Physical Properties of Rubber. Mr. Douty has kindly consented to read the paper to us on behalf of his friend Mr. Wormeley.

I. INTRODUCTION.

1. *Preliminary.*—The results of mechanical tests to determine the physical properties of rubber are influenced very materially by the conditions under which the tests are made. The form of test piece, test direction, speed of pull, temperature, and other factors appreciably affect the results of tension tests, and unless they are standard, or their effects are known and properly allowed for, the test may be of little value.

The writer is not familiar with the form of specifications used in other countries, but in the United States specifications for mechanical rubber goods frequently contain an outline of the methods to be followed, and a description of the tests in greater or less detail. Soft rubber compounds, such as are used in the manufacture of hose, packing, etc., are usually tested for elasticity, tensile strength and ultimate elongation ; and each of these properties is very materially influenced by temperature conditions.

The object of standardizing these tests should be to make the work of different laboratories comparable, rather than to secure great refinement in the matter of taking measurements.

2. *Factors influencing the Results of Tension Tests.*—The results of tension tests are influenced by the following factors :

1. Form of test piece.
2. Methods of clamping or holding in testing machine.
3. Direction in which test piece is cut (*i.e.*, longitudinally or transversely in the case of calendered sheet).
4. Rate and uniformity of speed at which test piece is stretched.
5. Temperature of rubber when tested.

These factors have all received the attention of investigators, and their effects upon the results of tests are known to some extent. Nos. 1 to 4 will not be mentioned further in this paper, the object of which is to present briefly the results of a few tests which illustrate the effect of temperature conditions on the tensile properties of rubber.

3. *The Influence of Temperature.*—Although the influence of temperature is generally recognized, its extent is not always appreciated, and often this influence is such as to cause discordant results, or even vitiate the test.

It is a matter of common knowledge among those engaged in the manufacture and testing of rubber, that a rise in temperature tends to increase the elasticity and ultimate elongation, but to decrease the tensile strength. If all rubber compounds behaved alike under the same temperature changes, it would be comparatively easy to prepare a set of correction factors, by means of which the results of tests made at different temperatures might be reduced to a uniform and comparable basis. The fact, however, that temperature affects some compounds much more than others makes it necessary to specify the temperature at which tests shall be made. In the United States, many laboratories have no provision for maintaining a specified temperature, and in many cases the room temperature may vary 30° F. or more from summer to winter. However, the careful attention recently given by testing engineers to rubber specifications and tests has resulted in more adequate regard for temperature effects. In the absence of any knowledge to the contrary, the writer has assumed that the matter of temperature effect is of importance to testing engineers in other countries as well, and it is hoped that the comparative tests described in this paper may interest those concerned with the testing of rubber. These tests were made with the view of studying the influence of change of temperature on elasticity (or what we commonly term " set " or " recovery "), tensile strength, and ultimate elongation.

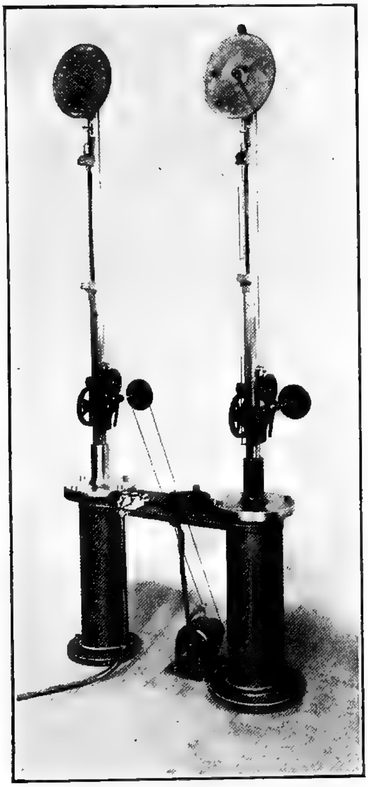

FIG. 1.

II. DESCRIPTION OF TESTS.

1. *Test Pieces.*—The samples, consisting of calendered sheet, were all of approximately the same thickness (3/32 inch) and since all test pieces were cut with the same die, their variation in width was practically

negligible. The test pieces were of the form shown in Fig. 2, and measurements for elasticity and elongation were made over a gauged length of 2 inches. The width, which was $\frac{1}{4}$ inch over the middle portion, was increased to 1 inch at the ends.

2. *Testing Machine.*—The testing machine (Fig. 1), for determining tensile strength and ultimate elongation was motor-driven, and the grips (shown in Fig. 2) were caused to separate at a uniform rate of 20 inches per minute. This type of grip, which was specially designed and has proved very satisfactory, is provided with a set of eccentric discs mounted on a pin. The discs act independently, and their faces, which are knurled, press the test piece against the smooth surface of the grip. Their action is such that a uniform pressure is exerted across the entire width of the test piece. This pressure increases automatically in proportion to the applied tension.

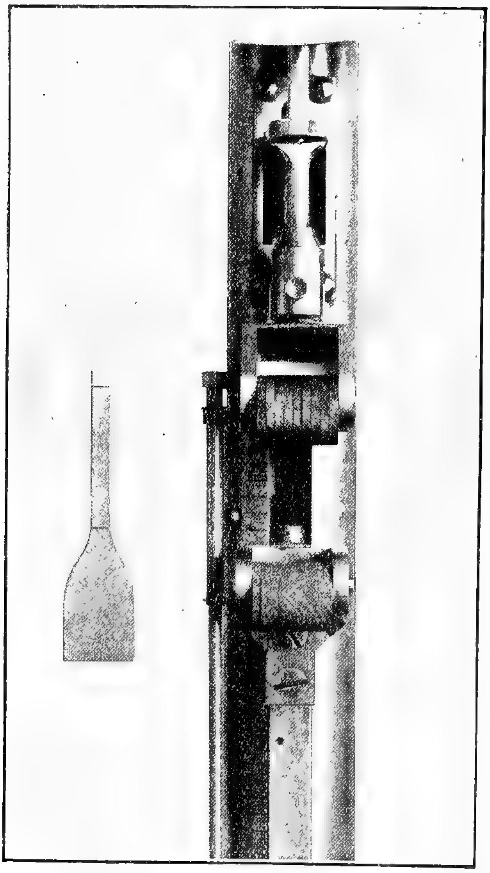

Fig. 2.

3. *Elasticity or "Set."*—In determining elasticity, the test pieces were stretched to the desired elongation in about 15 seconds. At the expiration of one minute (including the 15 seconds allowed for stretching) they were released and their extension or "set" measured after a rest of

1 minute. The elongation applied for each compound is recorded in the tables, where it will be seen that the stretch varied from 200 to 350 per cent., according to the quality of the rubber. The fact that the "set" in rubber does not vary in direct proportion to the elongation applied, makes this method of testing elasticity somewhat arbitrary. The tests were made as described, for lack of a better method.

4. *Measurement of Thickness.*—In order to eliminate any possible influence of temperature upon the measured cross-section of the test pieces, the specimens were all cut out and measured at the same temperature (about 70° F.). The thickness of each test piece was measured with a spring micrometer graduated to 1/1000 inch.

The measured thickness of rubber, if determined with a spring micrometer at different temperatures, would be influenced by the force with which the foot of the micrometer presses against the surface of the rubber, and also by the softness of the rubber. If, however, the foot is of sufficient area, the compression of the rubber under a moderate pressure, though varying somewhat with different compounds, is very slight in any case. When thin sheet, such as is commonly used in testing, is measured at different temperatures, the expansion due to a rise in temperature is accompanied by a corresponding softening of the rubber, with a tendency toward a slight increase in compression under the foot of the micrometer. It would seem, therefore, that the error introduced by this method of measuring would be practically negligible. This conclusion is verified by the results of a series of measurements made on twelve different compounds over a range of temperature varying from 18° to 130° F. The maximum variation in measured thickness was about one per cent.

III. Results of Tests.

1. *Chemical Analyses and Mechanical Tests.*—The chemical analyses of the samples are shown in Tables I. and II. The results of mechanical tests are shown in Tables III., IV., and V., and represent two series of tests, marked "A" and "B," which were made at different times but under practically the same conditions except as regards temperature. Each value in Tables III., IV., and V. represents the average of from four to eight tests. These results are illustrated graphically in Figs. 3, 4, and 5. In each case the room was maintained at the stated temperature for at least three hours preceding the tests.

A number of test pieces showed abnormally low tensile strength and elongation on account of small holes or particles of grit at the point of rupture, and such specimens are not included in the average results as tabulated. The results given in Table III. were obtained by using separate test pieces in determining "set" and tensile strength, and the results given in Tables IV. and V. were obtained by determining both the "set" and tensile strength of each specimen.

2. *Discussion of Results.*—These diagrams show the very great difference in physical properties (especially elasticity) resulting from such differences in temperature as frequently occur in a testing laboratory between summer and winter.

Comparing the diagrams with the results of the chemical analyses given in Tables I. and II., no definite relation appears to exist between the composition of rubber and its behaviour under varying temperature conditions.

A small difference in the time or the temperature of vulcanization, such as might be expected to occur under ordinary factory conditions, often exerts an appreciable effect upon the variation in physical properties due to temperature changes.

Referring to Fig. 3 and Table III., it was found in testing sample No. 2 for elasticity at 95° F., that the test pieces when stretched from 2 inches to 6 inches, and held, would break before the expiration of one minute, although this amount of stretch was within the ultimate elongation, which was 225 per cent. at this temperature. At 86° F. one half of the test pieces broke in the same way. This sample, and also No. 3, contained reclaimed rubber, as may be judged from their chemical analyses, but the percentage and quality of reclaimed stock is not known. The very decided change in the direction of their elongation diagrams between 75° and 95° F. is attributed to the presence of this reclaimed rubber which was observed to produce a noticeable softening effect at temperatures above 86° F.

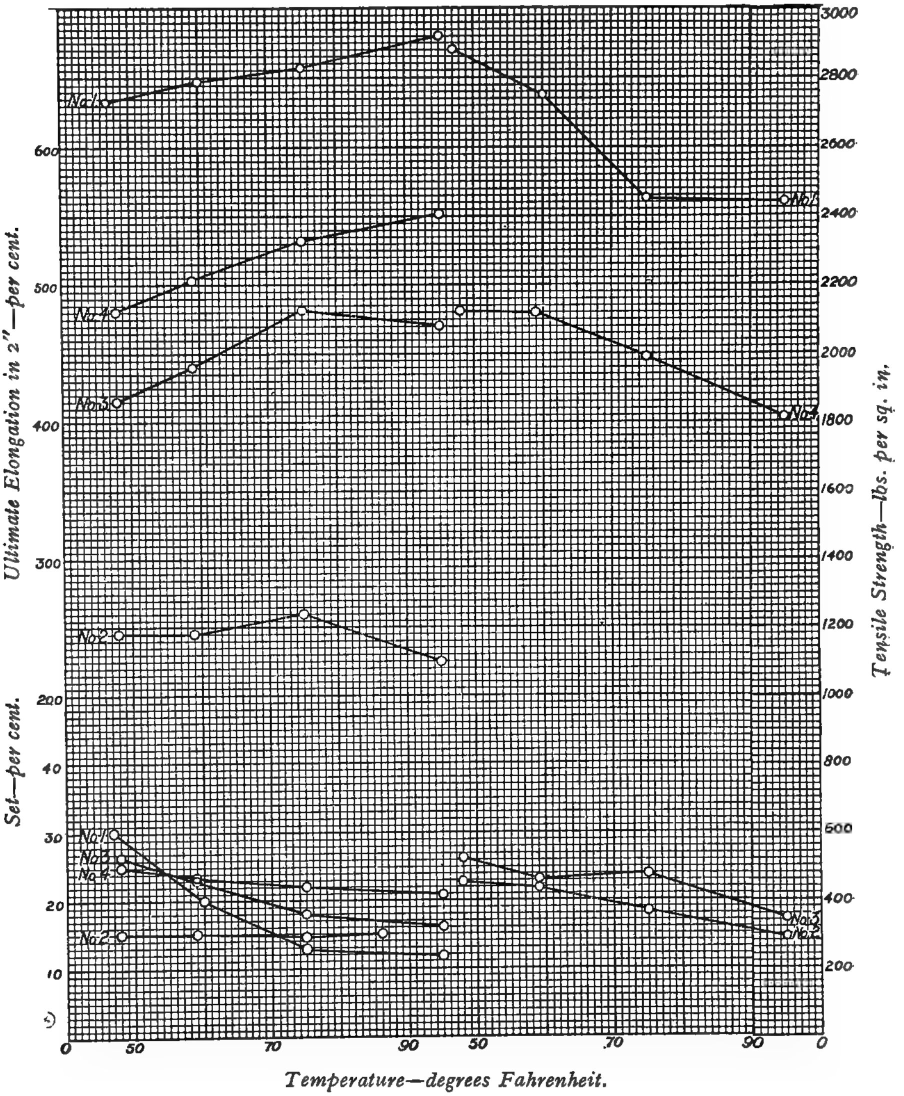

FIG. 3.

The fact that No. 1 (Fig. 3) shows the same tensile strength at 75° F. and at 95° F. is attributed to inherent variations in the material. The same compound tested under the conditions stated in Table IV. (Fig. 4) shows a very regular decrease in strength with rise in temperature, as would be expected.

With regard to elasticity (Fig. 3) it will be noted that No. 2 shows a constant "set" throughout its range; that No. 4 shows a very slight but practically uniform decrease in "set" with rise in temperature, and that Nos. 1, 3, and 4 show very slightly less "set" at 95° F. than at 75° F. Nos. 1 and 2 illustrate the very marked difference in the effect of temperature upon the elasticity of different compounds. At 70° F. these compounds show the same "set"—about 15 per cent. At 48° F. the "set" in No. 2 is still 15 per cent.; while the "set" in

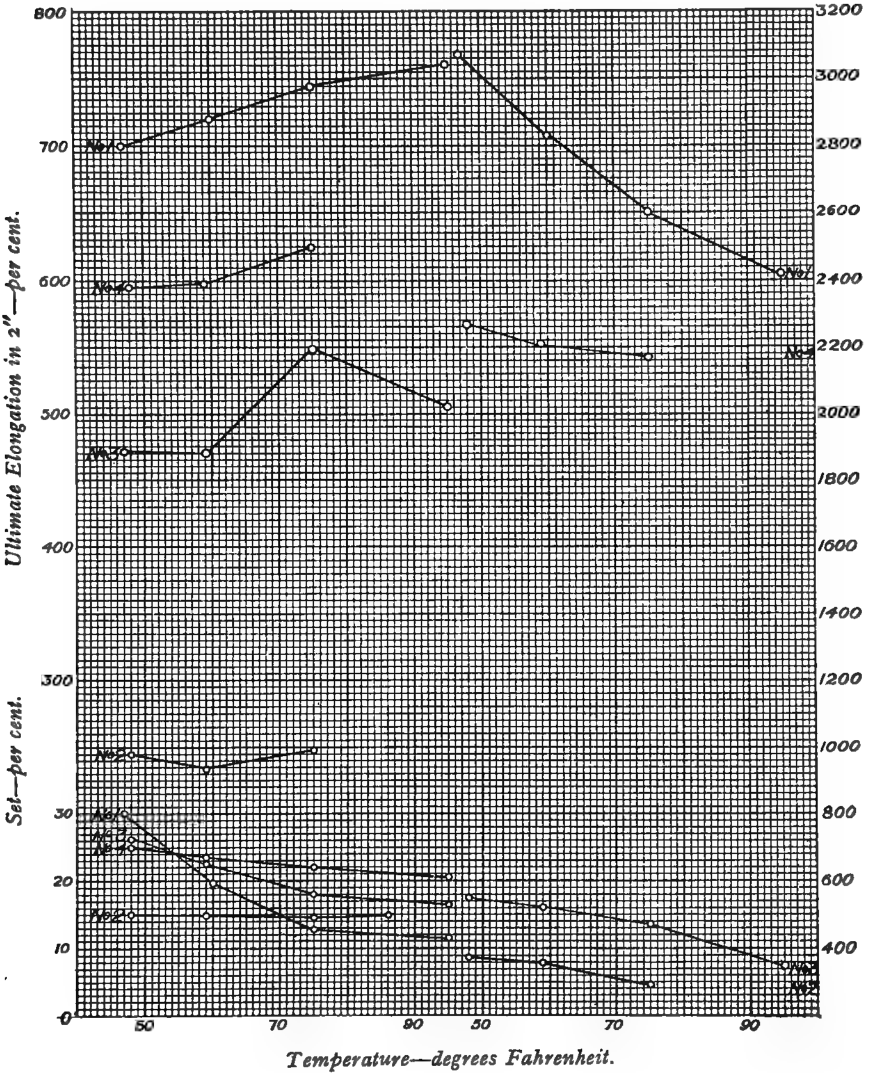

FIG. 4.

No. 1 is about 30 per cent., or just double the amount at 70° F.

No. 2 shows very little variation in ultimate elongation between 48° F. and 75° F., and with the exceptions already noted, Nos. 1, 3, and 4 show a general decrease in tensile strength and increase in ultimate elongation, with rise in temperature.

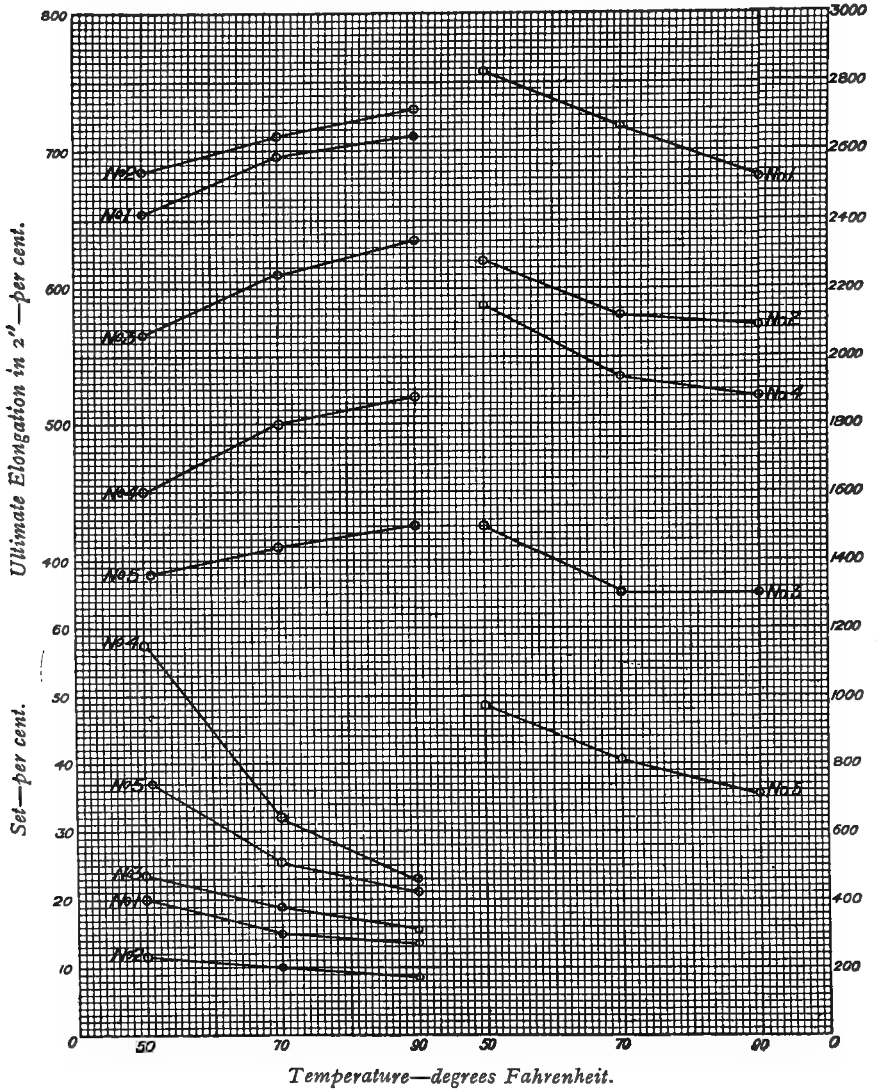

FIG. 5.

These results are practically borne out by the results plotted in Fig. 4, which represent tests for tensile strength and ultimate elongation made with the same test pieces that had been previously used in the determination of elasticity.

Fig. 4 shows no results for the tensile strength and ultimate elongation of Nos. 2 and 4 at 95° F. In the case of No. 2, the test pieces had been broken during the elasticity test, as already noted. In the case of No. 4 the test pieces that had been used in the elasticity test at 95° F. were accidentally destroyed before the test for strength and elongation. The diagrams in Fig. 4 show the very marked increase in strength and elongation over the values shown in Fig. 3, due to the previous stretching that the test pieces had received in the test for elasticity. It will be seen that the ultimate elongation of No. 3 was less at 95° F. than at 75° F., as was also found in Fig. 3.

Referring now to Table V. and Fig. 5, representing another series of tests, it will be seen that these compounds behaved in the same general way as those already described. In nearly every case a reduction in temperature from 70° to 50° F. produced greater effects than an increase in temperature from 70° to 90° F. It will be seen in Tables III., IV. and V., that in general the per cent. variation in " set " due to temperature change is far greater than the corresponding variation in tensile strength and ultimate elongation.

It is important that the purchaser as well as the manufacturer should know the effect of temperature on rubber, and this is particularly true in the case of a compound used in specification work where the requirements are rigidly insisted upon. In such cases the absence of a standard or specified temperature for testing may, and frequently does, lead to misunderstandings which are more or less serious according to the size of the orders involved. For example, assume that a contract is awarded for a certain class of rubber goods, and that the specifications include tests for elasticity, strength, and ultimate elongation with minimum requirements as follows:

Set 25 per cent., tensile strength 1,800 pounds per square inch, ultimate elongation 500 per cent.

Now if a compound such as No. 4, Fig. 5, were used, and the manufacturer made tests according to specification on a warm day when the temperature was, say, 85° F., he would obtain results about as follows:

Set 25 per cent., tensile strength 1,880 pounds per square inch, ultimate elongation 515 per cent.

As a result of these tests he would probably deliver the goods without considering the possibility of a rejection. Now suppose the purchaser tests samples from the delivery on a cool day, at, say, 60° F. He will obtain results about as follows:

Set 45 per cent., tensile strength 2,050 pounds per square inch, ultimate elongation 475 per cent.

The purchaser has no knowledge of the tests made at the factory, and with little or no data from which to estimate the approximate effects of temperature upon this compound, rejects the material for non-compliance with specifications.

In view of the frequency with which such differences occur, the importance of specifying the temperature at which tests shall be made is beyond question.

During the past few years, a very decided interest has been manifested in the comparative merits of different designs of machines for testing tensile strength, and attention is sometimes directed to the importance of calibrating and adjusting such machines from time to time to insure accurate results. Although the inherent variation in the tensile strength of rubber is known to be greater than 5 per cent., a testing machine whose error exceeds this figure would not be tolerated by the majority of testing engineers. In view of this fact, it seems rather inconsistent to base the acceptance or rejection of rubber goods upon the results of tests made without regard to the influence of temperature, which may vary from about 65° to 90° F.

IV. Summary.

1. In measuring the thickness of thin sheet rubber with a spring micrometer, the effect of expansion due to a rise of temperature is balanced to such an extent by the softening of the rubber that the variation in measured thickness rarely exceeds one per cent.
2. Temperature changes such as usually occur in a testing laboratory, greatly affect the physical properties of rubber.
3. No fixed relation is apparent from these tests, between the chemical composition and the tensile properties.
4. Elasticity is especially affected by temperature changes, and the absence of a linear relation between "set" and the applied elongation, makes the mode of describing such changes somewhat arbitrary.
5. In general, elasticity increases with rise of temperature, the increase with some compounds being many times greater than with others.
6. In general, elasticity is affected to a greater extent, and ultimate elongation to a less extent, than is tensile strength.
7. Tensile strength decreases with rise of temperature.
8. Ultimate elongation increases with rise of temperature.
9. Tensile strength is affected to a less extent in high than in low grade rubbers.

TABLE I.

Chemical Analyses (Series "A").

Sample No.	1	2	3	4
Acetone extract (cor.)	1·0	11·1	13·2	1·4
Ash	49·9	56·1	45·4	57·2
Total Sulphur (cor.)	2·5	4·1	3·3	3·1
Rubber	46·6	28·7	38·1	38·3
Free Sulphur	1·7	0·1	0·2	0·9
Barytes	8·1	40·7	15·9	none
Specific Gravity	1·67	1·75	1·42	1·72
Ratio, acetone extract to rubber	0·022	0·386	0·346	0·036

TABLE II.

Chemical Analyses (Series "B").

Sample No.	1	2	3	4	5
Acetone extract (cor.)	2·1	2·0	1·7	1·6	4·9
Ash	53·3	49·6	57·0	68·9	66·0
Total Sulphur (cor.)	2·1	8·3	4·1	4·7	7·0
Rubber	42·5	40·1	37·2	24·8	22·1
Free Sulphur	0·7	3·7	3·0	1·7	1·5
Barytes	15·9	none	21·9	none	0·6
Specific Gravity	1·64	1·63	1·62	2·22	2·00
Ratio, acetone extract to rubber	0·049	0·050	0·046	0·065	0·22

TABLE III.

INFLUENCE OF TEMPERATURE ON TENSILE PROPERTIES OF RUBBER (SERIES "A").

(Separate test pieces used for "Set" and tensile strength).

Sample Number	* Set in 2", per cent.					Maximum variation in terms of value at 75° F.	Tensile strength, lbs. per sq. in.				Maximum variation in terms of value at 75°F.	Ultimate elongation in 2", per cent.				Maximum variation in terms of value at 75°F.
	Stretched from 2" to	48°F.	60°F.	75°F.	95°F.		48°F.	60°F.	75°F.	95°F.		48°F.	60°F.	75°F.	95°F.	
						%					%					%
1	9"	30·0	19·9	12·8	11·3	146	2880	2755	2448	2434	18	633	647	657	680	7
2	6"	15·0	14·9	14·5	**	3	456	438	366	291	45	246	245	260	226	8
3	8"	26·5	22·8	18·0	16·3	57	525	465	479	349	37	415	441	482	470	11
4	9"	25·0	23·3	22·0	20·7	20	2124	2121	1994	1812	16	480	503	533	552	14

* Test pieces were stretched as stated for 1 minute, after which the tension was released and "Set" was measured after a rest of 1 minute.

** Broke before the expiration of one minute.

TABLE IV.

INFLUENCE OF TEMPERATURE ON TENSILE PROPERTIES OF RUBBER (SERIES "A").

(Same test pieces used for "Set" and tensile strength).

Sample Number	* Set in 2". per cent.					Maximum variation in terms of value at 75° F.	Tensile strength, lbs. per sq. in.				Maximum variation in terms of value at 75°F.	Ultimate elongation in 2", per cent.				Maximum variation in terms of value at 75°F.
	Stretched from 2" to	48°F.	60°F.	75°F.	95°F.		48°F.	60°F.	75°F.	95°F.		48°F.	60°F.	75°F.	95°F.	
						%					%					%
1	9"	30·0	19·9	12·8	11·3	146	3074	2834	2616	2415	25	700	720	745	760	8
2	6"	15·0	14·9	14·5	**	3	376	357	295	—	27	245	233	248	—	6
3	8"	26·5	22·8	18·0	16·3	57	553	521	470	350	43	471	471	548	505	6
4	9"	25·0	23·3	22·0	20·7	20	2264	2209	2173	—	4	595	598	624	—	5

* Test pieces were stretched as stated for 1 minute, after which the tension was released and "Set" was measured after a rest of 1 minute.

** Broke before the expiration of one minute.

TABLE V.

INFLUENCE OF TEMPERATURE ON TENSILE PROPERTIES OF RUBBER (SERIES " B ").

(Same test pieces used for " Set " and tensile strength).

Sample Number.	* Set in 2″, per cent.				Maximum variation in terms of value at 70° F.	Tensile strength, lbs. per sq. in.			Maximum variation in terms of value at 70° F.	Ultimate elongation in 2″, per cent.			Maximum variation in terms of value at 70° F.
	Stretched from 2″ to	50°F.	70°F.	90°F.		50°F.	70°F.	90°F.		50°F.	70°F.	90°F.	
					%				%				%
1	9″	20·0	15·0	13·5	43	2830	2670	2520	12	655	695	710	8
2	9″	11·5	10·0	8·5	30	2280	2140	2090	9	685	710	730	6
3	8″	23·5	19·0	15·5	42	1500	1300	1300	15	565	610	635	12
4	8″	57·5	32·0	23·0	108	2150	1940	1860	15	450	500	520	14
5	7″	37·0	25·5	21·0	63	970	810	705	33	390	410	425	9

* Test pieces were stretched as stated for 1 minute, after which the tension was released and " Set " was measured after a rest of 1 minute.

The CHAIRMAN : I may not have kept as close track as I should of the literature on this subject, but I do not remember to have heard this particular point developed to the extent that it is developed in this paper. I am inclined to think it a point that has been at least somewhat overlooked. It is an interesting paper, and I hope to hear a good discussion.

Mr. DOUTY : I would like to say that these are only preliminary tests. They are the first of a series got up to ascertain the relative magnitude of these effects, and we hope to be able later to carry out a very systematic series of tests with definitely proportioned compounds.

The CHAIRMAN : I admit that there does not seem to be very much ground for discussion when we are dealing simply with a straightforward statement of observed facts. It is rather difficult to see on what lines discussion can proceed, but one or two points may be raised.

Mr. B. D. PORRITT : Is there any question of the test pieces heating up ?

Mr. DOUTY : I think not ; the rate is so slow. The jaws separate at the rate of only 20 inches per minute.

Mr. W. G. MARTIN : Do you suppose from what you have seen so far that you will have to adopt a standard temperature to carry out the tests ?

Mr. DOUTY : I think that is so. Ultimately in these tests we will have to have the elongation at a certain temperature.

Mr. W. T. Gibson: I should like to ask if any attempt was made to separate the two effects of the softening of the rubber at a high temperature and its expansion or contraction. It happens that a fair amount of work has been done on the effect of temperatures on tests, and also upon the expansion of rubber at different temperatures. I was wondering, when it was found that rubber had a greater distensibility at a higher temperature, how far you have been able to separate the two things, the softening and the expansion.

Mr. Douty: No attempt was made to separate the effects. The samples were simply tested as samples and the study made on just what they do at those temperatures. It is hardly safe to make an analysis on results of this kind. About fifteen years ago I read the investigations of Sir William Crookes on the electric discharge in vacuum tubes. Sir William Crookes was one of the earliest investigators in that field. He worked on the subject for six years with very great exactitude and published some excellent papers in the proceedings of the Royal Institute. The experimental details are especially beautiful, but I was much struck with the fact that at the close of six years work he used the words "It is not safe to draw conclusions from the experiments." Many experimentalists would have drawn up some beautiful theories from them, but he was a careful investigator. With a series of results like this we should be very careful in saying what the effects are.

Mr. Gibson: The definition of temperature for making tests is made in many specifications. They say you must keep the rubber stretched for a certain time at a definite temperature. A little while ago I began looking into the literature on the question, but found that it was going to take up so much time that I gave up the pursuit. But one conclusion I came to, and it seems rather a high-flown idea, was that if ever I had to do with the starting of any rubber testing I should see that all the tests were carried out in a jacketed room that could be kept cool in the summer and have the temperature raised in the winter. The differences shown in the various papers that I read were great enough to give deceptive ideas as to the different qualities of rubbers. When I looked up the figures in the Rubber Growers' Association reports as to the comparative tests between different rubbers and noted the results found by Pierre Brueil and others as to differences in temperatures, I was convinced it was important that there should be a uniform temperature at which to make tests.

Dr. Esch: I would draw attention to the fact that uniform temperature of testing pieces for finding out the values of tensile strength and elongation would not be practicable in all cases, because in instances where mixings are taken containing a certain amount of components like balata and urac, etc., the temperature indicated in the lecture of 70 degrees Fahrenheit instead of 20 degrees Centigrade would be too high to give comparative values. I draw that conclusion from certain experiments that I have carried out during a period of more than ten years in a German rubber factory where I had to do a lot of work in testing balata belting. I found that in all the rubber-like substances they undergo a great difference as the result of different temperatures, and that in some instances 70 degrees Fahrenheit or 20 degrees Centigrade would be too high. It would be very easy to perform the tests at a lower temperature. As I was connected with this producing of balata I took my test pieces cooled in an ice bath. I draw attention to this point because the matter only seems a preliminary line nowadays and I feel that we should get into trouble if the Governments took suggestions and advice for adopting a temperature of 70 degrees Fahrenheit for general mechanical tests. I have made some observations with regard to Government regulations and rules, and have been told that in America some rules should be maintained prescribing that there should not be any use of magnesium. It would be strange of this should be prohibited only by the Admiralty regulations when it is accepted by the rest of the world.

Mr. DOUTY: I think that Dr. Esch is exactly right. It is not a question of prescribing a standard temperature and using that for everything. There would be soft compounds where that could not be done. But at the same time there should be a temperature, so that manufacturers and directors of works would be able to get concordant results.

Mr. STAFFORD WHITBY: With regard to the question of "set." It will be noticed that the set appears to increase with the diminution of temperature, and further that the curves are not parallel. Temperature appears to have a much greater effect on some samples. For instance, between 19 (?) and 50 it alters to a set of about 52 to 58. One curve is almost flat. I wonder whether Mr. Douty has any particular views as to whether that bears any relation to the quality of the rubber.

Mr. DOUTY: We would hardly at this time say that the change is an indication of quality. It is evident, however, that the one that has a straight line has the least "set," so that the amount of "set" would be an indication of quality.

Mr. GIBSON: I am curious to know if any tests have been carried out on tyres at higher temperatures, such as those ruling on the road in practice.

The CHAIRMAN: Plenty of tests are carried out on imitated road conditions.

Mr. GIBSON: But on test pieces at that temperature. I do not know of any.

Dr. ESCH: M. Brueil has some special apparatus, and has worked his test pieces very nearly on the same conditions as you get when a tyre is on a long trip on a wet road, so that it becomes hot from the interior and wet from the exterior.

Rubbered Balloon Fabrics.

By

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The subject of this paper is not quite as wide as its title may have led some of you to anticipate. I propose to deal with a number of points relating to the properties and testing of rubbered balloon fabrics, without attempting to enter into the question of the methods, precautions and details of their manufacture—with the latter side of the subject I can claim no intimate acquaintance and shall assume that most if not all of you are more qualified than I to deal with it. Further, for the sake of completeness, I shall be obliged to proceed as though you were practically unacquainted with those aspects of the matter upon which I have to touch; to those of you who have expert knowledge, much of what I am about to say must necessarily appear superfluous and perhaps unwarrantably didactic; to such I offer my apologies and must ask them to bear with me for the sake of those others to whom the subject is barely known.

DISADVANTAGES OF RUBBER.

In the first place it may be well to point out that although at the present time rubbered fabrics are almost exclusively used, at least for the non-rigid and semi-rigid types of dirigible airship, this supremacy is liable to be overthrown at any time unless further improvements are effected in their manufacture, since rubber suffers from several cardinal disadvantages and its employment is merely *faute de mieux*. For envelopes in which great strength is not required, such as those of small spherical balloons or the gas-bags of rigid airships, other materials are still frequently employed. Rubber is not a very impervious substance; as many of you are aware it is not even by any means perfectly waterproof, and when the fluid to be retained by it is gaseous its imperfections are more striking. The classical researches of Graham quoted in nearly every text-book on rubber illustrate the differences in the rate at which various gases can pass through a rubber membrane; he found that under similar conditions hydrogen diffused through his membrane some five and a half times as rapidly as air, a ratio which is considerably larger than that calculated from the ordinary diffusion law. (Carbon di-oxide goes through still more rapidly.) The consequence of this behaviour, which is usually attributed to the solubility of the gas in the rubber, is that rubbered balloon fabrics rarely leak less than five or six litres per square metre per twenty-four hours, whereas such materials as oiled silk and goldbeaters' skin can be prepared leaking less than one-fifth of a litre. Again, considerations as to the strength of the finished fabric militate against thorough vulcanisation of the rubber, with the result that the permanence of the product usually leaves much to be desired. Lastly, the weight of a light envelope constructed of rubbered cotton is much greater than that of an oiled silk of equal strength. But against these three drawbacks are set:

(I.) The pliability of the fabric, a necessary condition for the deflation and inflation of the balloon.

(II.) The absence of tackiness, at any rate while the rubber is in good condition; varnished materials are frequently inclined to stick, with results deleterious to the proofing.

(III.) The ease with which joints can be made, not only in the assembling but also in the repairing of the envelope.

(IV.) The possibility of combining by means of the rubber layer two or more plies of cotton so as to secure greater strength.

(V.) The use of cotton instead of the dearer silk which seems to be necessary when oil varnishes are applied.

Classification.

The obvious classification of the types of rubbered fabric required for various purposes is according to the number of layers of cotton which are combined in the finished fabric; we have thus materials containing one, two or three plies of cotton. The necessity of obtaining a thin uniform layer of rubber necessitates that in all classes the cotton basis should be closely woven and free from broken ends and slubs. A supply of a suitably strong cloth once procured, the manufacture of single rubbered fabric is a fairly simple development of the rubber-worker's industry. This single fabric is used for small spherical balloons, in which the strength is not required to be great, and for the gas-bags of rigid airships, in which the stresses due to the weights of the car, motors, etc., are carried by means of a metallic framework. For large non-rigid and semi-rigid dirigibles where the fabric is required not only to support the weight of the gondola and its contents, but also to withstand a pressure of gas sufficient to preserve the contour of the envelope, a much greater degree of strength is required. It is not practicable to obtain this additional strength by the use of stouter thread in the weaving of the fabric, since this would entail irregularity and undue weight in the rubber layer; accordingly two and sometimes three plies of fabric are used, the rubber serving to cement the different plies together. In order that the applied stresses may be fairly divided between the different plies, some care is required to ensure that the two layers of cotton are evenly stretched when the rubber is spread between them. A desire to reduce the liability to tearing suggested that in double fabrics the outer layer of cotton should be laid on diagonally, *i.e.*, with its threads at an angle of 45° to those of the inner layer; though achieving this object, the method naturally involves a relative loss of strength in the two main directions. To the consideration of the comparative merits of parallel doubled and diagonally doubled fabric we shall return later. In trebled fabrics the middle ply is almost invariably diagonal to the inner and outer layers. The exterior surface is usually provided with some medium for the absorption or dissipation of the light rays of short wave-length with a view to protecting the rubber from oxidation; the inner surface is generally protected by a thin layer of rubber in order not only to reduce the diffusion of gas, but also to prevent absorption of moisture and contact of the hydrogen with the cotton. The latter precaution was formerly necessary since the gas used contained impurities which might attack the fabric, but the use of improved methods of generation and scrubbing of the hydrogen has largely reduced the force of this argument. The portion of the envelope forming the ballonet, which is inflated with air for the adjustment of the pressure inside a non-rigid airship, calls for less complicated manufacture; on the one hand the inner septum is not exposed to light and consequently needs no protection therefrom, and on the other hand the ventral surface is only required to be moderately gas-tight, since it has to contain air instead of the more diffusible hydrogen.

TESTING FOR STRENGTH.

The testing of balloon fabrics presents several features of interest, and I propose to deal at moderate length with some of the conditions required for satisfactory testing and with a number of results obtained in the course of various tests. The first and perhaps the most important test is that for strength. The maker of the fabric may have been supplied with cotton of inferior quality or may have obtained less than the maximum strength for the cotton supplied to him owing to faulty conditions of application or vulcanisation of the rubber, etc. Those who wish to make use of airships may be disappointed if their envelope suffers from other defects, such as leakage, but they will be more than disappointed if the margin of strength available is insufficient to meet the extra demands made upon the fabric while in the air.

(A) TENSILE TEST.—With this test is frequently combined the determination of the extensibility; a considerable extension is of much value since errors of sewing, etc., are taken up without introducing any severe stresses. The simplest form of the test for strength is the widely used tensile strength test, *i.e.*, determination of the load required to rupture a strip of given width. In the textile industry two types of machine are in use; in the one type, of which the Goodbrand is an example, a constant rate of stretching is employed, the stress being measured either by a dynamometer spring or by the movement of a pivoted heavy arm across the quadrant of a circle; in the other type, such as the Avery machine, a constant rate of loading is used, the extension being taken up by hand adjustment. The latter principle appears to be the more scientific since fabrics do not by any means obey Hooke's law, that is the relation between the applied stress and the induced strain is far from linear, especially for low stresses. The Avery type of machine is required in most of the English aeronautical specifications and the remarks which follow must be understood to relate, in the first instance at least, to this machine. In all work on fabrics it is necessary to test a number of pieces taken from different parts of the roll in order to obtain a fair average, owing to the great variation in properties from one part to another. Not less than five tests should ever be made; the larger the number the more representative is the average. The factors which influence the results obtained by a tensile test on a given fabric are:—

(1) The dimensions of the test-piece.
(2) The rate of loading adopted.
(3) The quantity of moisture contained in the fabric at the time of testing.

(1) *Dimensions of Test-piece.*—The value of the tensile strength is expressed as so many pounds per linear inch (or yard). Accordingly it might appear reasonable to suppose that any width of sample might be tested and that the breaking load in pounds, divided by the width in inches would give the strength in lbs./in., no matter what was the actual width. Some experiments made at the National Physical Laboratory showed that this supposition is only moderately accurate provided the width exceeds some two inches; for strips narrower than this the tensile strength deduced is too great; for example, half-inch strips may give results four or five per cent. higher than those obtained with strips two or more inches in width. Further, the length of the test-piece also influences the result; tests made on specimens with one inch between the grips gave figures some twelve per cent higher than those obtained with specimens a foot long. Some part of these differences is probably to be attributed to the greater probability of the occurrence of a weak spot in the larger test-pieces, but the main factor is undoubtedly some sort of edge effect. The series of tests quoted in the Report of the Advisory Committee for Aeronautics, 1909-1910, p. 81, showed that for a single fabric the minimum width advisable was two inches, the minimum length six inches between the jaws. The use of test-pieces of smaller dimensions will give enhanced values for the tensile strength; moderate variation in the size of specimen above these limits will produce only small divergences in the results, but for the sake of uniformity and prevention of disputes it is well to insist on standard dimensions. It may be remarked that, whereas in the testing of ordinary textiles it is usual to cut out the test-pieces slightly wider than is required and then to fray down the edges until the desired size is reached, this precaution cannot conveniently be adopted in the preparation of samples of rubbered fabric for test, but one has to cut as accurately as possible parallel to the fibres.

(2) *Rate of Loading.*—A second factor which plays no small part in determining the results of tensile tests is the rate at which the load is applied. It is generally recognised that a prolonged strain will weaken any fibre; probably the twist imparted during the spinning operation is gradually overcome. At any rate it is found that when the rate of loading is very rapid the breaking stresses observed are considerably higher than when the lower rates are used. Since, in the subsequent life of the roll on which the tests have been made, it is impossible to ensure that accidentally high stresses shall always be rapidly applied, it seems reasonable to take the value found with the lowest rate of loading as the actual strength of the fabric in question; moreover, any errors of measurement due to lag in the action of the cut-off mechanism are naturally most serious when the loading is rapid. It has been demonstrated that with rates which require less than about three minutes for rupture there is an apparent increase in strength which may be, for extremely rapid tests, of the order of ten per cent. over the value found with the slowest rate which is practicable, *i.e.*, requiring some five to seven minutes. It is, of course, inconvenient to specify any one absolute rate for testing fabrics ranging in strength from 40 lbs. per inch to 120 lbs. per inch or more, but it is possible to insist that the rate of loading per minute should not be less than so much per cent. of the specification strength; this is equivalent to stating a definite time minimum which must be attained in all tests.

(3) *Humidity.*—The hygrometric state or "condition" of the cotton is also of importance. It is well known that cellulose fibres are considerably weakened by prolonged desiccation, and that a high degree of humidity in the air of the spinning and weaving factories is advantageous for the strength. The quantity of moisture hygroscopically retained by the fabric is a function of the relative humidity of the air with which it is in equilibrium, and variation of this quantity produces a concomitant change in the strength of the material. Experiments made in several laboratories have shown that for a difference of ten per cent. in the relative humidity of the atmosphere of the testing station there is a difference in strength of some four per cent. of the apparent strength of a fabric free from dressings. Since the relative humidity may easily vary from, say, 30% to 80%, the importance of this fact is obvious. The difficulty of regulating the atmospheric humidity has, however, militated against the general adoption of a definite hygrometric state; further, in the case of rubbered fabrics the attainment of equilibrium between the unexposed fibres and the air must be very slow and the time lag somewhat indeterminate. In the circumstances the simplest method will probably be to make a correction for humidity, in which case the exact magnitude of the correction must be definitely agreed upon in any specification; but in a large station where an installation for maintaining a constant hygrometric state of the air can be provided, the test-pieces could be freely exposed for a given number of hours before the actual test was made. The latter course has already been adopted in some foreign institutions, and such a procedure is now possible also, I understand, at the Manchester Testing House.

(B) COMPOUND STRESS TESTS.—The simple tensile test above outlined is ample for contractual and comparative purposes. For the calculation of the factor of safety in envelope design it is necessary to take account of the fact that the stresses on the fabric act simultaneously in both warp and weft directions, not in one direction only as in the ordinary tensile test, and that the strains in one set of fibres may be influenced by the tensions in the cross fibres. Compound stress tests are made in three different fashions.

(*a*) In a variant on the simple tensile test, crosses of fabric are cut leaving a square in the middle, the free ends being gripped by wooden jaws, and tensions are applied in each direction. A device, due to Mr. Horace Darwin, allows a constant and variable ratio of stresses to be employed throughout the tests. It has been noticed that considerable distortion usually occurs at the corners of the central square, so that it is evident that the stresses are not uniform across the area under test; hence there is some uncertainty in the interpretation of the results and in their correlation with those of tests under simple stress.

(*b*) The form of bursting test which can be carried out with the most readily constructed apparatus consists in the use of a flat disc of the balloon fabric which is clamped at its periphery to a box in which the pressure can be measured and gradually increased until rupture occurs. Here again the fact that the gripping of one portion prevents uniform distension of the central area makes the extrapolation to larger sizes of the values obtained a doubtful operation. Further, there is a considerable doubt as to the correctness of the formula used in converting the measured pressure and bulge into stress and strain per unit

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width. Still there is no doubt that information of some value can be obtained by such tests, and an apparatus of this nature is or was in use at the Lichterfelde Institute.

(*c*) The test to which least exception can be taken is the bursting of cylindrical bags of the material. The seam requires to be stronger than the remainder of the bag to ensure that rupture shall occur elsewhere; for the sake of symmetry a dummy seam is attached on the other side of the cylinder. The two circular ends are firmly gripped on well-fitting discs suitably attached to the testing machine, so that a longitudinal tension can be applied and measured; the interior of the closed bag so formed communicates with a system for applying and recording the pressure. The lateral extension must be known in order that the hoop tension may be calculated from the pressure; this is found by measuring the increase in diameter of the cylinder. As in other methods, there is a certain amount of distortion near the grips, but since the bags under test, which are some thirty inches in length, are sensibly cylindrical over all but the extreme inch or so, and the rupture occurs uniformly in the cylindrical portion, the results obtained by this method may be considered reliable. A large number of such tests have been made at the Royal Aircraft Factory and the N.P.L., and the following facts have been established:—

1. For parallel doubled fabrics the strength found by simple tensile tests is practically the same as that deduced from bursting tests. The elongation, on the contrary, is usually too great by something like a sixth of the true value, but the differences vary enormously with the ratio of the stresses.

2. Diagonally doubled fabrics, which in simple tension give practically the strength of one layer only, yield very different figures when the bursting test is applied. The strength in either of the two chief directions as deduced from the latter test may be, according to the ratio of the stresses, anything from 100% to 200% of that found by the ordinary tests on strips. The stress-strain relations are more complicated than when the two plies are parallel, and for information on this point reference should be made to the curves published in the Report of the Advisory Committee for 1911-1912. The conclusion arrived at from these tests was that for parallel doubled fabrics the simple tensile test was sufficient to check the quality of material of a given type of manufacture, a few bursting tests giving the information necessary as to the strains induced in this particular type. For diagonal doubled fabrics the ordinary test has only a limited meaning.

(C) TEARING TESTS.—The above tests for tensile strength of balloon fabrics are not in themselves sufficient to establish the relative suitability, even from the point of view of strength only, of different types of material for the construction of envelopes. The failure of a balloon is usually to be assigned to the occurrence of a rent at one part owing to local damage to the fabric. If, under the conditions prevailing at the time, the tear extends widely the consequences are serious, especially with non-rigid airships; if the tear can be prevented from spreading too far there may be a possibility of effecting a safe descent. Accordingly some test is required which will give a measure of the resistance to tearing. Different forms of such a test have been used; in some a small nick is made in the side of an ordinary tensile test specimen and the load necessary to continue the tear is determined. The test adopted at the National Physical

Laboratory for single and parallel doubled fabrics is as follows: A half-inch cut is made in the middle of a piece of fabric six inches wide by twelve inches long; this is then slowly loaded until the strip breaks. These dimensions have been found to be sufficient to eliminate the effect of size of test-piece on the result of the test. In comparing the two materials the figures to be considered are the ratios of the breaking loads so found to the loads required for rupture of an equally broad undamaged strip (calculated from the results of ordinary tensile tests on two-inch strips). It appears that a high extensibility is favourable to the tearing strength, the local distortions produced near the cut being more readily borne by the undamaged fibres. Diagonally doubled balloon fabrics possess a considerably higher resistance to tearing than parallel doubled fabrics made from the same cotton; in the bursting tests to which reference has been made it was noticed that with diagonal doubling the tear at rupture seldom ran the full length of the cylinder, as was the case with parallel doubled material. This improvement is obtained at the cost of a relative reduction in ultimate strength in the two chief directions. The virtues of the two types are more or less combined in treble fabrics, where the middle ply is diagonal to the other two, but except for very large balloons the extra weight so introduced is unduly great. As in the case of tensile strength determinations, a finally decisive tearing test must be made under compound stress; it has been proved that for single and parallel doubled materials the results obtained under compound stress are comparable with those found in simple tension, but for diagonally doubled fabrics the simple test is liable to be misleading, and in the present state of knowledge it is necessary that tearing tests on this class of fabric should be made under compound stress, that is by the method of bursting bags or possibly by the use of cross-shaped specimens as mentioned above.

PERMEABILITY.

Of importance only less than the mechanical strength is the gas-tightness of the fabric, since on this depends not only the cost of keeping the balloon inflated but also the possibility of remaining aloft for a prolonged period and hence the radius of action of the airship. When repeated "topping up" is necessary the purity of the gas is bound to suffer, with consequent reduction in the lifting capacity until it becomes necessary to scrap the whole of the contents of the envelope. As I mentioned in the beginning of this paper, rubbered fabrics are not at present by any means ideal from this point of view, and there is still room for experiment in the manufacture of the mixings. The addition of wax has been tried, with only partial success. A point which is probably deserving of further investigation is the influence of the degree of vulcanisation on the permeability of the rubber. The permeability is measured in litres of hydrogen per square metre of the fabric at 15° C. under a head of 3 cms. of water. The apparatus for the determination may be either static or dynamic. The earlier types were of the former class, *i.e.*, the measurement was of the diminution in volume at constant pressure of the gas enclosed between a disc of the material and a stout reservoir to which the disc was clamped as tightly as possible. The best known and most widely used of these static arrangements is that known as the Renard-Surcouf balance, but several others have been constructed by different workers. The objections to this class of apparatus are:—

(1) The gas becomes progressively more impure as the diffusion proceeds.

(2) The back diffusion of air into the enclosure causes the observed leakage to be too low.

(3) Any leakage at the ring of junction between the fabric and the remainder of the apparatus will at once vitiate the results, nor is there any means of knowing whether such leakage has occurred when abnormally high permeabilities are observed.

(4) Variations in the temperature and pressure of the external air cause changes in the volume of the gas, and the corrections to be applied may be of the same order of magnitude as the leakage to be measured. A box or room of fairly constant temperature should be used in order that the correction may be exact.

In spite of these drawbacks, the convenience of manipulation and the fact that the apparatus can be bought ready for use have caused a continued vogue of the static testers. For contractual purposes such tests are sufficient, but if it is desired to know what will be the actual rate of loss in lifting power of an envelope in question, a further test is required. It is not usually practicable to construct a small model and measure the lift from day to day: hence tests on the dynamical principle are necessary. In the apparatus designed at the N.P.L., the principle of which underlies some later forms adopted in other institutions, the defects above mentioned are practically absent. Instead of measuring an enclosed volume of hydrogen, a steady current of the gas is passed through the apparatus at constant pressure: the hydrogen is thus kept pure throughout the test. The gas which leaks through the fabric does not escape but is swept away by a current of air through an electric furnace and burnt with formation of water which is weighed by absorption in calcium chloride tubes. It is evident that leakage at the junction of fabric and apparatus is, on the hydrogen side, immaterial and, on the air side, of secondary, not primary, importance. Since the measurements are by weighing, the volume changes due to temperature and pressure are of no effect, the only difference due to temperature being the actual difference in permeability of the fabric.

(1) *Influence of Temperature.*—We may next discuss conditions which influence the results of permeability tests. The only factor which is of much importance is the temperature at which the tests are carried out. Investigations as to the magnitude of the temperature effect have been made at the National Physical Laboratory, and for the rubbered fabrics tested the variation in permeability was found to be of the order of 7 per cent. for every change of 1° C. This at once suggests the advisability of enclosing the apparatus in a box or room of constant temperature: where very accurate results are not desired and the type of fabric has previously been investigated it is usually sufficient to guard against large variations in temperature and to make a correction for the mean difference from 15° C. But for all absolute determinations it is necessary to instal an automatic temperature regulator of one of the usual forms. Since variations in permeability of 10 per cent. between the different parts of the same roll are not uncommon, a constancy of $\pm\frac{1}{4}$° C. is all that is required in most cases.

(2) *Influence of Hydrogen Pressure.*—Since the hydrogen in a balloon is, at any rate at the top, at a pressure somewhat above that of the atmosphere, it is usual to specify that the measurement of permeability shall be carried out at an excess pressure of

3 cms. of water. As this pressure is only $\frac{1}{300}$ of the total pressure of the gas, slight variations in the excess are of secondary importance: the concentration is practically unaltered and hence the leakage is not influenced from this cause, but since differences in excess pressure occasion alterations in the tension acting on the fabric it is advisable to adhere to the specified head. The examination of the effect of tension on the permeability offers several difficulties and does not yet appear to have been undertaken.

(3) *Influence of Purity of the Gas.*—The hypothesis usually accepted to account for the fact that hydrogen passes through rubber more rapidly than it should do according to the diffusion law, is that the gas, dissolved in the rubber on the inner side of the balloon where its partial pressure is 1 atmosphere, diffuses in solution through the rubber, and is evolved on the outer side where its partial pressure is zero. In accordance with this hypothesis it was to be expected that the rate of leakage should be proportional to the purity of the contained gas, *i.e.*, to the partial pressure of hydrogen therein. This corollary has been tested at the Laboratory for several mixtures of air and hydrogen containing from 0 to 100 per cent. of the latter gas: the curve connecting leakage with concentration of hydrogen was a straight line, within the limits of experimental error.

(4) *Influence of Moisture.*—A criticism levelled at the existing National Physical Laboratory apparatus, in which both the hydrogen and air are dried for convenience' sake, before reaching the fabric under test, was that the leakage of a normally moist cloth would be less than that found by this method, where the fabric is somewhat dried during the period of test. This point was settled by using moist gases in a few cases: no difference in permeability was observed.

WEIGHT.

A *sine qua non* for all balloon fabrics is that they shall be as light as is consistent with the necessary strength and impermeability. A weight of some 300 grs. per square metre is usual for doubled fabrics, while treble material for the most strained parts of the envelope may reach some 500 grs. per square metre. The determination of weight is of the simplest character: to obtain a fair average it is best, however, to weigh a considerable area of the material. In the textile industries it is usual to discount the effect of the hygroscopic moisture by weighing the sample in the "dry" state, but owing to the presence of the rubbered layers, such drying would be very slow and somewhat indeterminate, hence the humidity of the air is usually ignored, and the weights are ascertained without any preparation. This procedure is not as liable to provoke dispute as might be supposed: in the first place the difference in weight of cotton is only about 2 or 3 per cent. for the extreme differences in the relative humidity of the air with which it is in equilibrium; in the second place not only is one layer of a double cloth (or two of a treble fabric) almost insulated from atmospheric effects, but the waterproof backing probably very greatly retards the attainment of hygroscopic equilibrium in the outer layer.

ADIATHERMANCY.

In one particular, rubbered fabrics are usually considerably superior to oiled or varnished silks. Balloons constructed of the latter materials act as very sensitive radiation thermoscopes. On emerging from a cloud into bright sunshine the rays of shorter wave length as well as the heat rays are trapped as in a greenhouse and occasion a rise in temperature of the gas and consequent further ascent of the balloon: simple considerations of the effects induced lead to the conclusion that every variation in temperature difference between the hydrogen inside and the air outside the balloon, whether positive or negative, tends to diminish the period during which the airship can safely remain aloft. The perfect envelope in this respect should either reflect all incident light from its upper surface, or else be perfectly transparent to all rays, as well as being a good conductor in order that the gas may rapidly take up the external temperature. It is more nearly possible to obtain the former alternative: with this object applications of finely divided metal (aluminium dust) are frequently made to render the fabric better able to reflect or dissipate the incident rays. The efficacy of such and other methods of treatment of the fabric is compared by measuring the relative ratios of heat transmitted and heat absorbed by the fabric to the incident energy. The simplest form of the test consists in stretching pieces of the fabric to be compared over the mouths of suitably insulated boxes and measuring the rise in temperature of the enclosed air when exposed to sunlight. Some form of blank determination is necessary if the results are to be of any value for future comparisons. Where sensitive thermal apparatus is available several refinements suggest themselves: methods have been devised at the National Physical Laboratory which allow the measurement of the absolute quantities of energy incident, absorbed, reflected and transmitted, facilitating the solution of the whole thermal effect of radiation.

Adherence of Water.

Apart from the changes in weight which may occur owing to the hygroscopic nature of the external cotton layer a further consideration arises in connection with the passage of a balloon through a cloud or rain. The moisture deposited on the surface of the envelope should run off freely from the sides in order that undue increase in load may be avoided. Large differences occur in respect of this property between different types of fabric, *e.g.*, varnished silks are far superior in this respect to the ordinary cotton fabrics. Since the excess weight due to the selection of the rougher surface may easily amount to several hundredweight on a large airship, it seems that this point is worth the serious attention of manufacturers. The provision of a smooth and preferably waterproof outer covering need not occasion a large increase in initial weight. The difficulty in the use of rubber in this position is the rapid oxidation to which it is liable under such conditions: waterproof solutions of cellulose acetate are now sold for the purpose of doping the exterior of the envelope, but I have no data as to the value of these solutions for the purpose. Two methods have been employed for the comparison of fabrics from the point of view of water adherence. In the one method small strips of the fabrics are suspended in water for a given time and weighed after draining for two further fixed intervals: in the other method squares of about two feet side which can be hung on one arm of a balance are freely sprayed with water on the proper side. Edge effects are minimised in either case by waxing the edges. The former procedure is obviously open to the criticism that both sides should not be moistened, but since the adherence of water on the rubber side is practically nil the results obtained depend on the variations in external surface. As a matter of fact the figures given by the two methods are very similar : though the actual values for moisture retained per square metre are not identical the ratio for any two fabrics tested is very nearly the same in either case, so that the simpler method may be used for comparative results.

INFLAMMABILITY AND RATE OF PROPAGATION OF FLAME.

The safety of ballooning depends, probably in a larger degree than in any other form of transport, on the precautions taken to avoid accidents. The danger of fire is always present, and moreover for military balloons an obvious method of attack lies in the use of inflammatory projectiles. Hence there is no little advantage in the selection of a fabric which is as little liable as possible to ignition : closely connected with this question is that of the rate of propagation of flame along the fabric, since if this is low the size of the rent and the rate of loss of gas may be small enough to enable the damaged vessel to come to earth without further accident. The relative temperatures of ignition may be determined by passing a variable electric current through a thin resistance wire until the temperature attained is sufficient to cause inflammation : the rate of transmission of the flame may then be deduced from the area of the circle destroyed in a given number of seconds. Various collodion preparations have been suggested for the proofing of balloon fabrics, and the test readily affords information as to the degree of danger involved in their use. The temperature of ignition is fairly uniform among the existing rubbered materials which have been tested in this manner : the results as to the rate of propagation are liable to considerable uncertainty owing to the fact that in an actual accident there would be an additional supply of heat from the gas burning at the orifice produced, but in general the thicker the rubbered fabric the lower is the rate of extension of the burning area, owing to the relative deficiency in air supply.

WEATHERING.

Though naturally last in logical sequence the question of the changes induced in the fabric by exposure to the air, sun and rain is of vital importance. Any sudden changes in strength or permeability may produce disastrous effects, apart from considerations of expense and delay involved in the provision of a new envelope. Since the stability of the rubber layer is the factor of chief magnitude in the determination of the life of the fabric, various means of affording protection to the rubber are in use : to these I shall return later. Strange as it may appear, the deterioration of rubbered fabrics on exposure is discontinuous, *i.e.*, a balloon cloth does not become progressively weaker and less gas-tight. Uncoloured fabrics have been found to become stronger during the earlier stages of weathering and although in fabrics where the rubber is protected externally by yellow dye or pigment this effect is sometimes masked by the deterioration of the cotton which goes on concurrently with the retarded decay of the rubber, there is in almost all cases a stage where the permeability is enormously reduced, *e.g.*, from 10 lits. per square metre per day to ½ litre or less. Very shortly after this the strength falls more rapidly and the gas-tightness is practically destroyed. Hence any marked improvement in the impermeability of a rubbered envelope during its use is a warning that its life is nearly at an end. The probable explanation of this remarkable behaviour is that the rubber in the initial stages of its oxidation becomes more tacky or gummy and that this superficial change not only improves the adherence between the two plies of cotton but also tends to close up any pores previously existing; further deterioration of the rubber causes it to become friable and by the destruction of the cementing layer reduces the effective strength of the cotton combination. The course of the deterioration may be followed not only by the tensile tests and permeability tests, but also by chemical examination of the rubber. As is well known, the first products of oxidation are soluble in acetone: the rubber layer is therefore removed from the broken test-pieces and extracted with this solvent in a Soxhlet extractor. When this operation is performed on the new material a certain weight of extract is obtained, composed of the naturally occurring resin plus the uncombined sulphur: this weight is subtracted from the total extract found when the weathered samples are so treated, and the difference gives the weight of oxidised rubber. In the experiments made at the National Physical Laboratory the weathering was carried to very severe lengths and the maximum quantities of additional extract so obtained after very prolonged exposure varied, with different samples, from 7 to over 50 per cent. of the total weight of the rubber layer according to the quality of the rubber and the efficacy of the protection afforded. In one case, where the material was unprotected and the rubber of inferior quality, a further effect was noticed which may be of some interest in the chemistry of india-rubber. The acetone extract rose from 5 to 77 per cent. in a comparatively short time and then fell off to about 50 per cent.: the cause of this was found to lie in the further oxidation of the rubber to form a product insoluble in acetone, but dissolved by alcoholic caustic soda. The original soda extract of 2½ per cent. was increased to some 13 or 14 per cent. Analyses corrected for the quantities of resin originally present led to the approximate formula of $C_{10}H_{15}O_2$ for the oxidised material soluble in acetone, while the material soluble in alcoholic soda gave variable figures pointing to a higher content of hydrogen and a lower oxygen content, presumably due to the splitting off of CO_2 or similar bodies.

A second cause which may conceivably assist in the weakening of the cotton is the oxidation of the free sulphur occurring at the surface of the rubber with production of sulphuric acid. In the electrical study of ebonite, the fall in insulation resistance during exposure has been proved to be due chiefly to the development of acidity from this cause, and it is more than probable that such an effect occurs, in some small degree, in the case of the rubber used for balloon fabrics, in which though the absolute amount of sulphur is small the proportion remaining free is relatively large. Any acid so formed might be expected, in the case of cotton impregnated with chromate of lead, to cause a considerable acceleration in the rate of oxidation of the cellulose. But in the majority of cases the deterioration due to this action would be small compared with that due to destruction of the rubber, especially in view of the fact that the acidity present at any moment is liable to be removed by solution in the course of a shower of rain.

In the experiments on weathering, of which the chief general results have been mentioned, it was observed:—

(*a*) That the rate of deterioration was very much greater in summer than in winter.

(*b*) That in comparative tests where one set of specimens was protected from rain while a second set was not only not so protected but was regularly moistened and allowed to dry every day, the former set was much less rapidly attacked.

In view of the latter observation, weathering tests at the National Physical Laboratory are now conducted in the second manner, *i.e.*, by moistening daily, in order that comparisons may be more rapidly obtained. The exposure is admittedly much more severe than is likely to be the case with an airship, but there is no reason to assume that any difference in kind is involved. With regard to (*a*) the best method of obtaining more or less uniform results has been found to reckon the length of exposure, not in actual days, but in intervals of approximately equal amounts of solar energy incident on the fabrics. The meteorological records giving the number of hours of sunshine at a neighbouring place were insufficient, since deterioration obviously proceeds even if no sunshine is recorded: the most suitable instrument appeared to be either some form of bolometer or, as was ultimately adopted, a radio-integrator, which sums in a simple manner the amount of heat obtainable from the rays of light passing into a glass vessel. The exact interpretation of the readings given by this instrument is not at present possible, but owing to its convenience and to the fact that the readings, whatever their meaning, must be, more nearly than the count of days, a measure of the undetermined conditions causing the deterioration of the fabrics, it has been used in all subsequent weathering tests at the National Physical Laboratory.

It is generally believed that in the oxidation of rubber the actinic or short-waved rays of light are mainly operative. This belief is confirmed by the rapid deterioration of some rubbered fabrics which were exposed to the light of a quartz mercury arc lamp rich in ultra-violet rays. In view of this property it is usual to provide balloon cloths with a protective layer on the outside, of such a character as to absorb or otherwise arrest rays of this kind. The most widely employed method is to impregnate the external ply of cotton with yellow chromate of lead, and the results alike of laboratory work and of experience in the field indicate that a very great improvement in permanence is effected by this means. Unfortunately there appears to be some risk of weakening the cotton in the process of precipitating the chromate in its fibres: this difficulty, and perhaps also the fact that salts of lead are somewhat absorbent of heat rays, led to the use of yellow dyes for the same purpose. In spite of the fact that fast dyes are available, very few cloths of this kind have been found to withstand the weathering conditions of the National Physical Laboratory as well as those in which the chromate process has been carefully performed: the colour of the dye has usually disappeared after quite moderate exposure. In connection with the question of diathermancy it was mentioned that applications of aluminium powder have been used to prevent the transmission of solar energy to the interior of a balloon. Several German cloths are provided with such a coating and some have been made in this country, but conclusive experiments are still lacking to show whether some form of this procedure may not entirely replace the yellow colouring so widely prevalent.

The problem of permanence may also be attacked from another point of view. I have previously drawn attention to the fact that the deterioration of fabrics is much less rapid when they are protected from moisture: this may be due to peroxide formation during the evaporation of the water or to some similar autoxidation phenomenon. Hence waterproof dopes may serve a double purpose, and further study in this direction may be illuminating.

Though other tests may frequently suggest themselves in special cases, such as chemical examination of the rubber and fibre layers, microscopic investigation of the cotton employed and the action of various agencies on the material, the tests outlined above are usually sufficient, at least for contractual purposes. But, as may be gathered from the foregoing remarks, the testing of balloon fabrics calls for no less careful consideration than that of other materials of construction. In the diversity of the desiderata of the finished envelope the problems to be attacked by the manufacturer are certainly as complex as those requiring solution in other branches of the industry, and the frequency of the occurrence of defects in use shows that the subject of balloon fabrics is worth the more serious attention of rubber workers.

The CHAIRMAN: This is a subject concerning which we have all been waiting for illumination. I think we have it this time. I have never before had any conception of the difficulties encountered in devising tests which would meet the requirements. It is not so much the practical difficulties of balloon construction that have impressed me as the difficulties of conducting tests in such a way as to make certain that the desired result has been realised. With as many present as there are this morning who must have a considerable interest in this matter we should have a good discussion of the paper.

Dr. ESCH: I have been working as an adviser to manufacturers especially of balloon fabrics, and so have found myself deeply interested in this paper. I will make a few remarks which may perhaps help those of my colleagues who are interested on the same lines. I do not wish to indulge in any criticism of the points brought before us by the lecturer, but only wish to make some remarks from the manufacturer's standpoint. We have made a series of tests, especially with chromate colours, with the object of investigating whether they have a serious effect on the balloon fabrics. We have found that for the most part they have a destroying effect on the rubber. We have also found that there is a very good means of obviating the use of these chromate colours, in the employment of a special kind of rubber to rubberise the fabrics. There exists a kind of Para rubber which has a very light yellowish colour. I mean the so-called Peruvian Mollendo rubber. It is not equal in all respects to fine Para, but we have found on tests that it gives very good results for making balloon fabrics, and especially in making fabrics for airships. I must refer to the fact that if you overdo the colouring of your balloon fabrics, you have serious danger. I am sorry that we have had too much proof of this danger in Germany, and have lost many good people by accidents which have perhaps been due to the formation of too much electricity by the friction of air on the big surfaces of our airships.

Dr. SLOCUM: Has the National Physical Laboratory investigated the dyes reported on by Dr. Kenneth Mees, as to their absorption spectra, light-fastness, etc.? The report is made in his work on tri-colour filters for three colour photographic work. Effective protective dyes for rubber fabrics should be found there. The information regarding the bad effect of moisture on rubbered balloon fabric would indicate that the oxygen found in the rubber tended to combine with the free sulphur, the rubber acting as a catalyst. SO_2 is the gas most soluble in rubber. It is even more so than CO_2. In the presence of moisture it would produce sulphurous acid, and the final effect would be the production of sulphuric acid by the further action of the dissolved oxygen. Dr. Esch's statement that sulphuric acid has actually been found under these circumstances would confirm this supposition. Has Mr. Guy Barr noticed any increased ill effect of moisture when a large excess of free sulphur is present in the rubber?

Mr. B. D. PORRITT: I know that for years past the annual report of the Committee on Aeronautics at the National Physical Laboratory has been awaited with great interest. An interesting point in Mr. Barr's paper is connected with the oxidation products found in india-rubber proofing. About a year and a half ago we thought the question of oxidation products had been thoroughly settled. The first compound formed was supposed to be $C_{10}H_{16}O$, which is a soft resin. On further oxidation a hard, brittle substance containing three atoms of oxygen was supposed to result. Apparently the old results are more in accord with what we have just heard stated. Mr. Barr has not referred at all to some work that I believe he has had proceeding in conjunction with Mr. Thomas on the subject of the use of gelatine as a substitute for india-rubber in proofing fabrics. I should like to know the results they have obtained. Gelatine I should fancy would be extremely difficult to employ where a tight seam is required. It would also in addition, I think, lack the necessary elasticity to withstand stretching, and moreover would probably be inclined to be brittle when cold, and might develop defects under tension. Coming to another point of the paper, it is my impression that lead chromate has been superseded by aniline dyes, this being due to the fact that darkening occurs in vulcanisation by sulphur. Another point is as to the effect of sulphur. Excess of sulphur is probably in the amorphous form, and would tend to crystallise and increase the diffusion. A matter to which I would like to refer is the effect of accelerators. It might be advisable to employ litharge or magnesia as accelerators. It would be of interest to know if any information is available with regard to the effect of the addition of mineral matter on the diffusion. Another point, which Mr. Barr stated was not very important, was the estimation of moisture in the fabric. Probably it does not affect him, but it might affect the manufacturers. In the case of a balloon fabric vulcanised by steam heat, it might be at somewhere about 270 degrees Fahrenheit, it is probable that a little moisture will remain in the fabric. The raw fabric might contain 10 per cent. of moisture. This on curing is completely removed, but by the time it has been taken to the balloon shed and has lain round there until examined, a fortnight or a month might elapse. During that time a large proportion of moisture might be re-absorbed, and then the difference might be greater than you anticipate. With regard to Dr. Kenneth Mees' work on dyes, I should like to know whether you can compare the results of a dye on a fibre with the results of a dye in solution.

Dr. SLOCUM: Such a comparison should not be made without a careful test.

Dr. ESCH: Dr. Slocum has mentioned the great solubility of SO_2 in rubber, and the big disadvantage of such material. I may state that it has been proved in practice that it is not practicable to use hydrogen which is made by metallic zinc and sulphuric acid, because it contains vapours of SO_2. In Germany we lay great emphasis on the necessity for chemical purity of hydrogen. In most cases the hydrogen for such purposes is made by using metallic zinc and quicklime, which gives off very freely fine pure hydrogen. As to the moisture problem, it is difficult to get away enough moisture in drying before the fabric is rubberised, because the fabric after drying has an extraordinary tendency to get moisture from the air. The vulcanised rubberised fabric has a certain tendency to take up moisture from the air. In dealing with the determination of moisture it may be of interest to the gentlemen present at this Congress to know that we have found it to be expedient to effect distillation simply with a little xylol. The vapours after condensing show the xylol and the water very easily separated and easily to be determined. We have found that you cannot obtain an agreement of the values used if you make a comparison of drying fabrics in any way but by this xylene method.

Mr. FREDERICK KAYE : There is one interesting point in this very fascinating paper, that is, the repeated evaporation of moisture from the fabric deteriorating the fabric. Some years ago I found that if I took the crude rubber and determined the resin content, and at the same time the so-called moisture content, and repeated the experiment at different periods of time, as the resin content increased the moisture content increased. There was some relation that I have not worked out. In Mexico about three or four years ago I did some experiments with Plumaria latex, in determining the amount of material left in the mother liquor after the coagulum had been removed. If I took ordinary water and alcohol I found the difference in the residue was very great. In the case of distilled water and alcohol there was a very small quantity of material left, as compared with acid substances, or ordinary tap water that contained lime. I think this has an interesting bearing on the effect of repeated evaporation of moisture on the material.

Dr. ESCH : As to the determination of moisture in crude rubber and vulcanised rubber : the evaporation tests generally give quite wrong results. We have in our laboratory used the xylene method. I think that in many cases here this method is nearly unknown to colleagues who are interested in this line of analytical work.

Mr. GIBSON : With regard to the diffusion of nitrogen it has been found to be very slow indeed, as compared with oxygen. If my memory serves me, of the common gases nitrogen is the slowest of diffusion through the membranes of the rubber.

Mr. PORRITT : Sir William Ramsay has found with all the gases that their diffusion is practically nil through the rubber membranes.

Mr. GIBSON : I would like to ask whether the method of dyeing by solution has been tried. The rubber may have deteriorated so much by the time the dye is bleached that it may not be in time. While I am on my feet I would like to say that it might be better for the plantation and the manufacturing interest in rubber if they came into closer touch with the National Physical Laboratory.

Mr. KAYE : With regard to my remarks on moisture content, I do not believe it is moisture really. It is something else.

Mr. BARR : I am very grateful for the various suggestions made in the course of this discussion, and am quite interested to hear of the use of yellow rubber for balloon fabrics. With regard to frictional electricity in the air, I did not touch on that, because it seemed to me that the desiderata for the envelope are still somewhat undecided. Some tell you that it should be a perfect conductor, and others that it should be a perfect insulator. Either view seems to explain the accidents that have occurred. At present it is difficult to know which is to be preferred. With regard to the application of Dr. Kenneth Mees' tables of absorption spectra, there are several difficulties such as the variation of the positions of the absorption bands during fixing on the cotton and the question of fastness to water. Work on this subject has been contemplated but not yet undertaken: I hope to have an opportunity of attacking the question before very long. The question of the presence of excess of sulphur in the rubber is obviously one of considerable importance, especially in view of the point which was raised about the solubility of the sulphur di-oxide in the rubber. With regard to the permeability of the fabrics to oxygen and nitrogen it seems that, although these gases get inside, this is considerably less important than the permeability to hydrogen, since the actual lift of the balloon is scarcely affected by the diffusion of either oxygen or nitrogen into it. On the subject of the use of gelatine, it hardly comes within the scope of a Rubber Congress, but I may say that the experiments are being continued. There is considerable difficulty due to the stiffness of the gelatine, even in the presence of glycerine. I have no information as to the effect of mineral matter on the diffusion. The effect of moisture on fabric, as one speaker pointed out, is probably rather more important to the manufacturer than to the tester, but I may remark that the difference in weight of the roll when it leaves the factory and when it reaches the laboratory is not entirely a disadvantage all on one side. If you gain moisture during the exposure of the fabric as it comes along to be tested you probably gain considerably more strength. I suggest that it is of considerable importance that some means should be adopted either of standardising or getting a proper amount of moisture into your middle plies so as to get better strength. The evaporation of water on the rubber surface seems to have attracted the attention of many people, but I think the effect of the ultra-violet rays of light during that evaporation must also be considered a factor. They are considerably more predominant in the upper layers of the atmosphere than where the tests are made. As to re-dyeing, I have not heard of this being done, but usually when the dye has faded the rubber has perished so far as to make re-dyeing out of the question.

Synthetic Rubber.
(Researches on the Commercial Preparation of Isoprene).

By

GASTON CHARDET.

On the invitation of the Chairman this paper was read by Dr. E. M. Slocum.

The object in writing this paper is not to epitomise the whole history of the discovery of synthetic rubber, nor to review all the processes, patented or not patented, which their originators claim to be practicable, profitable, or simply capable of being realised. One may say at once that there are too many of them. In this department of organic chemistry a phenomenon unique in the history of the science has been witnessed ; an abnormal efflorescence of discoveries and of patents launched upon the world by inventors, well-meaning, if not always the most capable. Unfortunately, it would seem that the mountain has once more brought forth a mouse, and, after the great clamour raised in the beginning, one may be forgiven for being a little surprised at the feebleness of the latest arrival in the firmament of commercial synthetic chemistry. Having at first caused floods of money to be poured out, synthetic rubber is now causing floods of ink to be poured out, and at the moment chemists are split up into two clans—the synthetists and the anti-synthetists.

The synthetists say " Patience, oh ye of little faith ! Has not chemistry always commenced in the professor's laboratory before becoming popularised in the factory ? Science is the beacon of commerce. Alizarine, synthetic perfumes, and the like, are all proofs of this co-operation. Ionone has not hindered the increase in the sale of natural violets." The anti-synthetists reply, " Synthesis is only useful if the cost of the raw material is low ; if the initial cost is high there is no object in it."

In one way the synthetist is at the mercy of any rise in the cost of the raw material, since by the inexorable law of supply and demand, when one renders a useless product a thing of necessity its price is sensitive to slight variations, and on the other hand he has to reckon with the possible reduction in price of the natural product with which he is competing. It must not be forgotten that if certain synthetic perfumes have had a long existence (synthetic musk and natural musk having an equally large sale) it is because the difference between the two is such that there can be no question of competition, the one being in the class of cheap products and the other in the highest class. There is as much difference between the two as between truth and falsehood. The same thing is seen in the rubber industry. Rubber substitutes have not dethroned natural rubber because they could not ; being at best a supplementary product and not a replacement of the natural product, they therefore do not quarrel with each other.

In case of a product like synthetic camphor, the claims made were greater, and the artificial product competed directly with the natural product, but the double danger was there and could not be got over—increase in the price of terebenthine, the raw material, and the diminution in the price of natural camphor.

But is that saying that synthetic rubber will have no practical result ? Certainly not, but what I will say is that one section of the investigators have directed their inquiries into the wrong path. The inventor who tries to make rubber starting from hydrate of β—methyltetramethylene hexamethyldiammonium (Swiss Patent 51·276) seems to me to run the danger of waiting a long time for the realisation of his dream, *i.e.*, great factories with their towering chimneys dispensing to an astonished world unpuncturable tyres made from synthetic rubber.

The most common starting point in rubber synthesis is spirit of terebenthine or its derivatives. Personally I have obtained good yields of isoprene from volatilised dipentene passed over metallic cloth heated to dark redness. The dipentene itself was obtained by the dehydration of terpinëol.

The methods which rely on the use of terebenthine, terpene, etc., seemed to me to be destined to receive a check, even supposing the yield of isoprene to be 60 per cent., which it certainly is not, and that is why I abandoned my researches in this direction.

The materials which seem to us to be most suitable for economical experiments are :

Oil of naptha.
Resin oils.

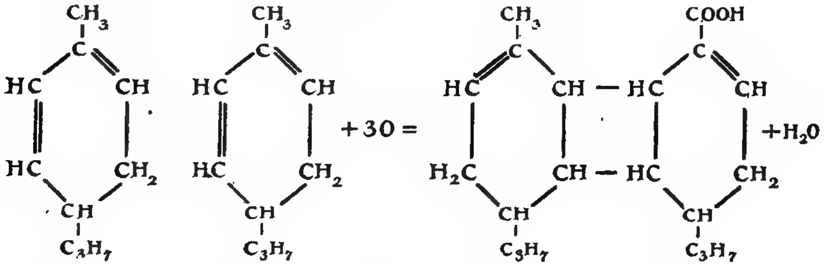
Our actual tests were carried out with resin oils.

1. Resin Oils. Resins are a product of the oxydation of terpenes by means of acids, and their formation may be theoretically explained by the following equation :

$$2C_{10}H_{16} + 3O = C_{20}H_{30}O_2 + 3H_2O$$

This equation supposes that complete oxydation takes place in the acids obtained from colophony, abietic acid, for example.

Taking the formula of Pahrion one would get :



In the resin oils, produced by distilling resin, the products are different and the pinene nucleus is altered and probably transformed, the phellandrene nucleus by hydrogenation.

In view of the above formula, I attempted to hydrogenate them. I employed the following method : I passed the resin oil steam charged with hydrogen over metallic cloth (iron) rolled in a porcelain tube, heated to dark redness. The distilled product was treated with calcium chloride to dehydrate it and was then rectified. From this we obtained products:

1. A five carbon body identical with isoprene.
2. A dipentene distilling near 170°.
3. Some cymene and some phenanthrene (oxygenised products easily made resinous).

The yield of isoprene was small. We obtained in our experiments an average of 8 per cent. to 12 per cent.

It must not be forgotten that the by-products and residues were of appreciable commercial value.

It is clear that it would be possible to vary the products obtained and render them more interesting by studying different calalytic agents; reduced nickel, for example.

Our experiments will also apply to naphtha oils, *i.e.*, either to the fraction of them containing isopentane, or with the paraffin series.

We repeat that it is probably in this direction that the economic solution of the problem of synthetic rubber will be found; simple pyrogenic reactions, aided by calalytic agents, permitting the breaking down of complex hydrocarbons, by a simple process of oxydation and reduction, aided by catalysis.

Pyrogenic reactions could be advantageously applied to the production of amyl alcohol, but the stumbling-block here lies in the high price of the product. We must wait until the method of production of this product by fermentation can be accomplished on a commercial scale.

We must wait, if without exaggerated enthusiasm, still with confidence. The results may not be so brilliant as the first inventors hoped, but what does matter after all is that the search after synthetic rubber has encouraged the work of chemists and manufacturers, has enriched science by a great number of new products, and has brought out of obscurity a hidden chapter of organic chemistry.

In such investigations the public sees only the money result. That is an error. The result is nothing—the effort is everything, and the value of the work must not be measured by its success. Synthetic rubber is not a great *industrial* discovery, but it will be none the less a great *scientific* discovery.

Dr. Slocum: I may say regarding this matter that I have had considerable experience of synthetic work, and the reference here to synthetic perfume is very misleading. No synthetic perfume has ever replaced the natural product. It has always provided a new odour, or a new variation. Natural musk and artificial musk are two different types of that odour. Artificial musk is not necessarily cheaper than natural musk, and in fact there are some kinds that cost more than the natural musk. The dependence that the writer of the paper places upon the commercial possibility of side products is thoroughly fallacious. In the matter of the dry distillation of coal and so forth by the Siemens process this has been a success, but in no case where a by-product is formed from a chemical reaction has any real commercial benefit been found from the by-product. It has to be produced and forced on the market, and it has to be sold. It is always a great nuisance. The most probable possibility regarding synthetic rubber is the utilisation of the low boiling forms of the paraffin olefines series in the way of gasolene and other compounds obtained by freezing natural gas. That has become a very extensive industry in America. They crack petroleum and build it up by a certain amount of this frozen gas, which dissolved in the cracked kerosene, gives it the same efficiency as natural gas. I understand that the Standard Oil Company are converting 8 per cent. into gas. The one hope of the synthetic chemist is to produce new rubbers useful in new directions. The production of a new gutta or a new type of balata or something of that kind would seem to me the most happy aim for the synthetic chemist to work at.

The CHAIRMAN: I take it that in your allusions to by-products, Dr. Slocum, you are speaking of the case where the by-product has to be taken out of the factory and thrown on the market. You are not alluding to the possible employment of the by-product in the synthetic process itself?

Dr. SLOCUM: Oh, no. Simply to the commercial utilisation of the by-products. In making 1,000 lbs. of rubber you would make 5,000 or 6,000 lbs. of dipentene. The only use for that at present is the adulteration of lemon oil, and I doubt if there is enough lemon oil made to give a real outlet.

The discussion then closed.

Substitutes Derived from Oxidized Oils.

By

GASTON CHARDET.

The Chairman announced that he would himself read the second paper by M. Gaston Chardet.

The high price of rubber, especially in the last 10 years, has had the result of directing experiment towards the discovery of substances having the properties of natural rubber, but at lower cost price, from which has been born the rubber substitute industry, or, to speak more correctly, the manufacture of artificial substitutes for rubber.

Unfortunately, although a large number of patents have been taken out, there are few which have realised the hopes of their inventors when it comes to commercial results. For many of them the question of the initial preparations was a deadly stumbling-block, because in chemistry the law of similitudes does not always hold good, and an experiment which succeeds very well in the laboratory on a small scale may be a dead failure from a manufacturing point of view, the influence of the reactionary masses being enormous. In the reclaiming of rubber this has clearly been seen, because in manufacturing many difficulties were encountered which were not foreseen in the laboratory, and if the principle has been retained the method of operation has certainly had to be altered.

A large number of patents have been abandoned simply because the inventors had forgotten, too many of them, that a rubber substitute worthy of the name must possess resisting, elastic and supple qualities which were totally lacking in their products.

These substitutes may be classed as follows :—

1. Substitutes from oxidized oils.
2. Substitutes from oil vulcanised by sulphur or by chloride of sulphur.
3. Substitutes made from gelatine, the cellulose esters, amylaceous substances, etc.

It is not our object to review here all the different substitutes, as they have been frequently described elsewhere. I shall simply deal with substitutes made from oxidized oils, and shall describe my experiments in the oxidation of various oils by means of ozone.

Chemical Constitution of Oxidized Oils.—Some oils when exposed to the air, change their properties and appearance very quickly. They become acid or rancid, and take on a brown colour. Some undergo a still greater change in that they lose their fluidity and solidify to semi-elastic resinous products. These are known as " drying " oils.

Chevreul, when studying this singular property of drying oils, observed the action of atmosphere oxygen in bringing about this result, and he demonstrated the accelerating action of finely divided metallic lead. De Saussure, who carried on similar researches, confirmed the action of oxygen, and regarded the resinification mentioned as nothing but simple oxidation. Cloez, however, showed that the reaction was much more complex, and that the oxidation was accompanied by loss of hydrogen and carbon. He also established the accelerating effect of heat, of metallic oxides, of metals, and, in a lesser degree, of sunlight; he confirmed the formation of volatile acids and of a solid matter which he considered a definite compound without, however, being able to give any information as to its chemical nature.

We have to go to Mulder for more definite research. This chemist observed the presence of an oleaginous acid (linolëic acid) in linseed oil, differing from the oily acids of non-drying oils, and conceived the idea of isolating it. He proved that this body was easily transformed by contact with the air first into oxylinolëic acid, and afterwards into a solid *neutral* substance, linoxine, a true oxylinolëic anhydride.

Mulder's experiments, then, threw a new light upon this interesting question, but nevertheless the mechanism of these reactions is still unknown. New workers followed up the researches of Mulder, viz., Hazura, Bauer, Friederich and Grussner, and they have given a rational, if not complete, explanation of the oxidation of drying oils. We shall briefly review their work.

They have demonstrated that all the liquid acids of linseed oil contain 18 atoms of carbon in the molecule.

$$\begin{array}{lll}
\text{Oleïc Acid} & .. & C_{18}H_{34}O_2 \\
\text{Linolic Acid} & .. & C_{18}H_{32}O_2 \\
\text{Linoleïc Acid} & .. & \multirow{2}{*}{$\left.\right\} C_{18}H_{30}O_2$} \\
\text{Isolinoleïc Acid} & .. &
\end{array}$$

Olëic Acid, not giving a solid product when oxodized by air, plays no part in the formation of linoxine, and quantities of linolic, lionlëic and isolinolëic acids contained in the oil, are determined by the velocity of the oxidation reaction. Oxidation does not consist solely in the saturation by oxygen of the free valences of the unsaturated fat acids, but also in the substitution of hydroxyl groups for hydrogen atoms, thus giving birth to alcoholic groups.

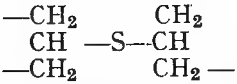
Oxidation will also produce glycerides (glycide products) in glycerine, which explains the acidity which occurs in this product. The final principal by-product, through oxidation and dehydration of the glycerine is an oxylinolëic anhydride (a compound observed by Mulder), and which constitutes, as we have already seen, the substance called linoxine, or more correctly, oxylinolëin, a change which may be represented chemically as follows :—

$$\begin{array}{l}
C_{17}H_{28}\text{—COO—}CH_2 \\
C_{17}H_{28}\text{—COO—}\dot{C}H \\
C_{17}H_{28}\text{—COO—}\dot{C}H_2
\end{array}$$

This is the glyceric ether of linolëic acid or trilinolëin. The linoxine has the following formula :—

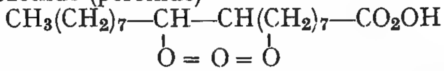
$$\begin{array}{l}
CH_2\text{ —}C_{17}H_{27}\text{—CO . OC—}C_{17}H_{28}CH_2 \\
\dot{C}H\text{ —}C_{17}H_{27}\text{—CO . OC—}C_{17}H_{27}CH \\
\dot{C}H_2\text{ —}C_{17}H_{27}\text{—CO . OC—}C_{17}H_{27}CH_2
\end{array}$$

This formula suggests the possible welding of another linoxine molecule, which is quite probable, since oxidation is accompanied by polymerisation, a fact which is proved also by the sulphuration of oils, in which case the adhesion of two molecules of the glyceride is assured by an atom of sulphur.



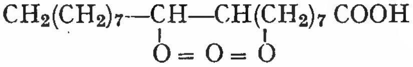
$$\begin{array}{lll} -CH_2 & & CH_2 \\ CH & -S- & CH \\ -CH_2 & & CH_2- \end{array}$$

ACTION OF OZONE UPON OILS.—Oils are capable of absorbing a large quantity of chilled ozone, forming viscous products which are not stable. Harries and Molinari studied the action of ozone on olëic acid, which forms an ozonide (peroxide)



$$\begin{array}{c} CH_3(CH_2)_7-CH-CH(CH_2)_7-CO_2OH \\ O = O = O \end{array}$$

which, treated with water, gives an unstable normal ozonide by losing an oxygen molecule.



$$\begin{array}{c} CH_2(CH_2)_7-CH-CH(CH_2)_7\,COOH \\ O = O = O \end{array}$$

Molinari and his co-workers experimentally determined the "ozone figure" for oils, and demonstrated that this could be calculated exactly from the iodine figure of these oils, the ozone associating itself to the non-saturated groups, *i.e.*, the CH groups of the fatty acids. It is therefore evident that the greater quantity of the unsaturated oily acids and oil contains the more oxygen it will absorb, and that the oils containing linolic acid, with two ethylenic linkings, and linolëic and isolinolëic acids with three ethylenic linkings, will fix more oxygen than oils rich in olëic acid which have one ethylenic linking only. This is what is borne out by experience, the figure for linseed oil being 33·5, while for olive oil it is only 15·9.

ACTION OF HEATED OZONE.—On passing ozone into heated oil the reaction is complicated by dehydration and polymerisation, and assists in the rapid formation of Mulder's linoxine, which forms only slowly when atmospheric air is used, but more rapidly with ozone because of its peroxidizing properties.

In our tests we combined the action of heated ozone with that of a metallic salt, which acts as a carrier of oxygen after the manner of resinate of manganese. The reaction under these these conditions attains the maximum of rapidity and intensity.

Linseed oil with 1 per cent. of resinate of manganese was heated for 2½ hours with a current of ozone. Abundant liberation of gas and irritant vapours (probably acrozëin). The ozone is easily absorbed, and when no more can be absorbed it is run into a porcelain cup and allowed to cool. The result is an elastic mass of a brown colour.

Hempseed oil or Poppyseed oil with 1 per cent. of resinate of manganese was treated after the same manner. Result: a more fluid elastic mass than that obtained above.

Fish oil with 1 per cent. of resinate of manganese. Result: a tenacious elastic mass.

Conclusions. We must conclude that at this time, when substitutes for rubber are being sought for by the most extraordinary methods, the products obtained by the oxidation of oils should have attention rather than those obtained by the action of sulphur, since the former are much more elastic than the latter. It appears to us also that these by-products could be used for linoleum, as they are so rapidly prepared. They have, it is true, the drawback of being highly coloured, but it might be possible to remedy this by carrying out the oxidation at a lower temperature.

Our experiments have had no other end in view but to draw the attention of manufacturers to the possible utilisation of ozone as a practical factor in the preparation of hardened oils.

In concluding, I wish to thank Mons. Dardare, electrical engineer of the Society for the Sterilisation of Water by Ozone, for so kindly placing at my disposal the necessary ozone for the carrying out of my experiments.

Dr. Slocum: In a material so sensitive to oxidation as rubber the reduction of so highly oxidised a body as this highly ozonized oil gives rise to oxidation of the rubber itself, and its subsequent cracking. Has anyone ever noticed any troubles of this kind with blown oils and so forth ?

The Chairman: I fancy that in that case oxidation does not proceed to anything like the extent that it does here. I take it that his final products in this case contain ozonide. Is there anyone who can throw any light on that question ? I have had no experience with it myself.

The discussion then closed.

The Advantages and Defects of Plantation Rubber.

By

W. A. WILLIAMS,

General Works Superintendent of The North British Rubber Co., Ltd.

In introducing the subject I wish to state that my remarks are those suggested solely from the handling in manufacturing operations of plantation rubber, and the experience gained therefrom, especially during the last few years when large quantities have passed through my hands. They are not directed in any way to adverse criticism, being simply statements of fact made with the hope that those connected with the plantation industry will be brought closely in touch with the manufacturing difficulties as they exist to-day, and that the appreciation of these difficulties will pave the way to experiments and investigation to so improve the resultant product that more confidence and reliability will be given to the use of this grade. This, all said and done, will be just as much to the benefit of the plantation industry as to the manufacturer, the natural result being that greater quantities will go into consumption, to the financial gain, I hope, of us all.

Whilst the subject of this paper—The Advantages and Defects of Plantation Rubber—at first sight reads something like a qualified compliment, I must acknowledge that the title does not convey my opinion of this class of rubber. The expression looks more like that of a pessimist than of an optimist—for on the question of plantation rubber I am optimistic enough to believe there is a big future for it; but we must not blind ourselves to the fact that everything is not yet just as it might be, and so I framed the title of this paper as it stands. When I have finished you will, I trust, understand its meaning better, and appreciate the difficulties the manufacturer is constantly facing, and the help he has given to the plantation industry, even although his object was so materialistic as £ s. d.

As I have already stated, my remarks will be based entirely upon observations of manufacturing facts as they have presented themselves to me in the factories of The North British Rubber Company, Limited. Being statements of fact and the opinions obtained therefrom, I bring them forward, not into the field of controversy, but for consideration and discussion with those interested in plantation production, as a means of, as far as possible, evolving the best methods of overcoming difficulties now existing, and as a basis on which we may work together. My experience, I have no doubt, has been quite adverse to many views, especially as to the form in which the rubber should be prepared, but it is the experience of practical factory handling, and I wish you to consider it as such.

Reviewing as a whole the question of the uses of plantation rubber, there are two points of view when making comparisons with this grade:

The first—and I suppose the foremost, as it is this phase that is principally and almost entirely discussed—is its comparison with Pará grades; and the second—a consideration which is given less prominence—is its comparison with mediums, such as the whole range of Africans, centrals, ball, etc.

Let us for a moment consider the second view first; and it is well worthy of a few words, as the introduction of plantation rubber has been the means of displacing mediums to a very great extent, if not entirely. And why? Simply because its use in the factory has given less trouble in manufacturing operations and better products, with the attendant reduction in manufacturing costs. A grade of rubber is to our hands which is undoubtedly of better average quality, is more easily worked, and gives more reliability than we get with the whole range of mediums. If we have variability in plantation rubber, we certainly had the same difficulty to contend with when manufacturing with medium grades, and those with factory experience will no doubt remember the many troubles which presented themselves when using these grades. Such questions as vulcanisation difficulties, porosity, and storage troubles in connection with the finished article, were not at all unknown factors to contend with, and if plantation rubber has helped to minimise these worries, we at the factory end are ready to acknowledge and appreciate that fact. I mention this aspect of the situation especially as I am afraid that in discussions it is often forgotten, and due credit is not given for what we must acknowledge as an achievement, which has helped materially to give more confidence in the quality of rubber goods as turned out to-day.

In specification work, where goods have to be supplied to a chemical specification—a demand which has arisen practically during the last few years—and at the same time in work where the finished product is not called upon to stand the mechanical strain of a Parà mixing, plantation rubber has entered largely into consumption, to the benefit of all concerned, including the purchaser. Were it not for this grade of rubber, with its analytical figures such as extracts, etc., equal to those of Pará, it would not be possible to manufacture except by the use of Pará; for, as you all know, a medium rubber with a resin extract of anything up to 20% would be out of the question, and consequently the purchaser would be called upon to pay so much more for his goods, without, in many cases, getting any better return in the way of longer or better life from them. In these capacities, chiefly as a displacer of mediums, plantation rubber has made a bold bid for the market, and has been successful. It will, I am of opinion, retain the position it has gained; so that from the second point of view we can, I fancy, leave it unchallenged, the achievement being one of:—

(*a*) Increased consumption, to the benefit of the Plantation industry.
(*b*) Improvement of manufacturing conditions, to the benefit of the manufacturing industry.
(*c*) More reliable goods, and in some cases better prices, to the benefit of the purchaser.

Before leaving this side of the question and passing to the comparison with Pará, I would just like to mention a few very instructive figures which show how the demand for plantation rubber has increased in the factories of The North British Rubber Company, Limited. In themselves they are sufficient to prove my point that something is to be gained by its use, or you may be sure such increases would not have taken place. The figures speak eloquently as to whether we find this grade of rubber suitable for our requirements or not.

The first serious attempts to use plantation rubber for manufacturing purposes in our factories were made in 1907, and in this year and the following the consumption was not very large; but once its qualities were established the consumption steadily increased, and it is still progressing, the figures being as follows:—

Increase for	1908	over	1907	.. ..	1,000%
„	1909	„	1908	.. ..	2,000%
„	1910	„	1909	.. ..	350%
„	1911	„	1910	.. ..	150%
„	1912	„	1911	.. ..	100%
„	1913	„	1912	.. ..	100%

The fall in the percentage is accounted for, of course, by the fact that the increase each year is on a larger total, and although the percentage has decreased the total increase in weight is very large, and even for the last year's working we used double the quantity consumed in 1912. I might say we have not yet displaced all the grades by plantation rubber, although I have no doubt our plantation friends would like to see us do so. At the present moment I cannot promise that we shall be able to do this, as there are many difficulties to face. This brings me back to the first point regarding the direction in which the biggest increase is now to be looked for, namely, its use in place of Pará. This is the question that is always foremost in discussions, and rightly so, in that it is the object of the plantation industry to turn out their rubber equal to, and as reliable as, hard fine Pará. In speaking of plantation rubber just at present, I mean the class as a whole, and I am not sub-dividing it or considering the respective merits of unsmoked biscuits or sheet, smoked biscuits or sheet, creped or block. As to the relative merits of these for manufacturing purposes I will say a word or two later.

I think I am right in saying that we are all fairly well in agreement that the average plantation rubber as a whole being turned out to-day is not equal to Pará, either in respect to:—

(*a*) Uniformity, or
(*b*) Strength.

In handling Pará it is perhaps remarkable, when one considers the conditions under which it is collected, that it should be shipped in such uniform consistency. Washing losses are practically constant, and in the further manufacturing operations its behaviour is quite uniform. Under equal conditions, time and again, no change has to be made when manufacturing with this grade. Such difficulties as vulcanisation troubles do not present themselves, and in fact, the conditions of manufacture can be so specified that no material departures from them are necessary.

In the fabrication of plantation rubber a very different condition of affairs presents itself. It is true that washing losses are constant, and in this respect it certainly offers distinct advantages over Pará in that the percentage loss in the washing department shows a lower figure. But this is a minor point, and if in the preparation of plantation rubber some method were devised which gave greater uniformity, and the process were one which called for delivery in a damp condition, the manufacturer would not be one to object, as allowances for such loss can easily be made in the purchase price, and if a constant washing loss in Pará can be obtained then plantation rubber should present no difficulties under this heading. I mention this point in passing, as often considerable claim is made for plantation rubber on this question of loss, and in some quarters it might be considered a move in the wrong direction if the present mode of preparation in respect to moisture content were departed from. This is not my view, if the manufacturing conditions are to be improved.

When one comes to the handling of plantation rubber in the factory, here perhaps the greatest difficulty of all presents itself, namely its variability. Unless due care is taken to guard against these difficulties, especially when carrying out the vulcanisation operations, considerable loss both of time and money will inevitably result. In respect to these vulcanisation difficulties, we in the factory find ourselves in very little, if any, better position than when handling mediums, except that the trouble with porosity has become less acute. It must be acknowledged, however, that if conditions are carefully adjusted we undoubtedly achieve a finer finished product ; but as compared with Pará we have entirely different circumstances. As some indication of the manner in which variability affects factory conditions, I would like to mention as a case in point some adjustments in respect to vulcanisation which are examples of quite recent work :—

MOULDED GOODS.
Heat increased from 60 mins. @ 50 lbs. } or 16·6%
to 70 ,, ,, ,,
OPEN STEAM CURE.
Heat increased from 2½ hrs. @ 270° F. } or 40%
to 3½ ,, ,, ,,
WRAPPED GOODS, OPEN HEATED.
Heat increased from 40 mins. @ 50 lbs. } or over 100%
to 80 ,, ,, 52 ,,

I think you will agree that when such adjustments have to be made there is no denying the fact that some factors are at work in the preparation of the crude which are having very serious results when the rubber goes into consumption, and if we can find means to minimise, if not obviate, these variations, the sooner the better for all concerned. There is no question but that if this were accomplished it would mean larger consumption of this grade in the manufacturing industry.

On the question of strength I am not prepared to say that the advent of greater uniformity is going to give us plantation rubber equal to hard fine Pará. The adjudication of this point is, in my opinion, one of the greatest difficulties just now presented to the industry, and I hope at this Conference we shall hear something on the subject. I have seen figures quoted, and have had examples through my own hands of plantation rubber where such tests as stress and strain figures have given results quite equal to Pará, and one would be tempted to say from these figures that the rubber was equal to Pará ; but when put into use and subjected to conditions where considerable fatigue was put upon the rubber—in such articles, for instance, as catapult cord—it was found to fall down. In fact, nothing but Pará will make this class of goods.

Such facts have convinced me that simple tests like stress and strain are not sufficient to judge upon, and a more reliable and conclusive method of testing is wanted at present, unfortunately. The final and only reliable method of testing is that obtained by samples being put into use, and, so far as my experience goes, for certain particular operations I have not found it possible at the present juncture to replace Pará with plantation rubbers.

I think I have sufficiently well indicated the variability we have to meet with in manufacturing operations, and it might be of interest to mention in passing, just in outline, the methods adopted in the factories of The North British Rubber Company, Limited, to cope with these difficulties, and the arrangements in operation to reduce the risk of loss that would inevitably follow without proper scientific control. The standard we set for our supplies is such that the rubber delivered can be used either for general work or for specification orders, without having to divide the rubber further when passing to the mill. When tender samples are passed, the delivery in bulk is expected to be equal thereto. Crude rubber on being delivered to the factory, before it is passed to the washing department, is carefully examined and analysed by the Mill Supplies Laboratory, and on their passing, can go forward for manufacturing. By this means the rubber coming forward to the manufacturing departments can be indicated in advance, and adjustments made accordingly. Outside the question of assurance of the quality being up to the mark by the laboratory examination, a great difficulty in the employment of this grade is adjusted, namely that of vulcanisation, where big differences, as I have already indicated, are experienced in the actual works operations, and where there is a likelihood of considerable losses being made if proper scientific control is not kept over the operations.

Without efficient scientific control such as I have briefly outlined, I am confident in saying plantation rubber cannot, at present, be successfully used, and in factories where it does not exist, the lack of this organisation may be sufficient to condemn the use of plantation rubber entirely. A factory manager is not likely to continue using a grade of rubber which brings with it loss and uncertainty of manufacture through the variability of the crude he is using, and unless he is in the position of having an experimental department running, so to speak, ahead of his large operations, he is bound to strike trouble.

This is then, briefly from my experience, the only way, as conditions at present exist, of dealing successfully with the situation. It is obvious, however, that if anything can be done to reduce this trouble and variability, it would be greatly to the interest of the manufacturer, and just as much so to the plantation industry, as with more confidence greater consumption is bound to follow. It is to our united interests to have these faults, if not entirely eliminated—which is perhaps impossible—at least reduced to a minimum, and this naturally at once prompts the question—how ?

I am afraid that I am not competent and my experience is not such, that I can say anything about estate work and the methods in vogue for collecting and coagulating the latex. These are matters quite outside my province, but upon the finished product of the estate as delivered to the manufacturer I might be allowed to say a few words which will, I trust, indicate to our plantation friends what we do want, and what we do not want ; and they will, I hope, from these indications devise such methods as will ultimately give us what we are looking for.

At the outset in dealing with a question so crucial, one must appreciate the fact that some factors exist on the estates which materially influence the finished product ; such, for instance, as age of trees, variation of climate, soil, etc., and these are obviously quite outside the control of any estate manager. But on the other hand, there is much that is under control, and if only uniformity of methods can be adopted, I feel we should derive much benefit thereby ; such, for instance, as the operations of tapping, coagulation, and preparation of the coagulated rubber. Under this latter heading, I am afraid there is much diversity of opinion. I give you my observations and opinions as they have presented themselves to me from a manufacturing point of view, obtained from handling these different classes of rubber.

In deciding upon the class of plantation rubber for use in the factory we have the choice of :—

1. Unsmoked Biscuits or Sheet.
2. Smoked Biscuits or Sheet.
3. Creped Rubber.
4. Block Rubber.

After repeated trials I have found that unsmoked biscuits or sheet gives the best all-round results, and is to be recommended for the reasons, that for strength and uniformity it is quite as good as smoked sheet, and is undoubtedly superior to creped or block rubbers. With creped rubbers I am afraid the planters have sacrificed everything to appearance, the one object in view, apparently, being the turning out of a nicely finished and attractive looking product, without much thought to its subsequent behaviour in the manufacturing industry, entirely losing sight of the fact that the manufacturer is not at all interested in the pretty appearance of the rubber he is buying, but is, on the contrary, vastly interested in the results he is going to obtain in his product in the directions of strength and reliability. Creping and grinding of the rubber should, in my opinion, be left entirely to the factory side, and it should be the aim of the planters to turn out their rubber as strong as they possibly can. It is extremely difficult to understand what advantages can be expected by having the nerve of the rubber destroyed by the creping rollers, which, of course, must take place. It is one of the rudimentary principles of rubber manufacture that milling or creping materially reduces the nerve and strength of the rubber, so why do it when the cry is all the time for strength ? I would not be surprised to find that this creping process so soon after coagulation has a very detrimental effect upon the rubber—far more than the ordinary breaking down process followed by the manufacturer when he grinds for the purpose of mixing and calendering. Another well-known fact in the trade is that grinding materially affects the vulcanisation properties. In fact the rubber can be so worked that the subsequent vulcanisation becomes one of the greatest difficulty. Efficient vulcanisation on an overworked rubber may become an impossibility, and considerable trouble may also be encountered from porosity. It is, therefore, obvious that creping on estates is a feature that is bound to accentuate these troubles and give loss of strength, together with vulcanisation difficulties, and I am of opinion that trials made upon this class of crude have been the cause of many adverse comments upon the employment of plantation rubber generally.

I think it is acknowledged that the quality of a rubber cannot be sufficiently judged by appearance or hand-pulling. Samples which, if judged by these tests, would be considered superior to others of doubtful appearance—say bad colour, for example—have, on manufacture, proved to be inferior, so why should this practice of creping be continued, and so much attention be given to turning out a rubber with a pretty appearance, a matter which is of no practical interest to the manufacturer ? The attention and money expended on these operations might, in my opinion, be more profitably employed in other directions, to the benefit of the resultant product. We should be without the detrimental effects of this treatment, anyway, for I am fully convinced that no good results or improvements are effected, and it is a fallacy to imagine that appearance will sell the crude. Results count first, and no matter in what form or appearance the rubber is put on the market, if the quality is there, quality will do the selling. Pará does not sell on outward appearance, and no thought is given to this factor. My remarks have been rather strongly expressed on this point, which I know affects so many interests, but I have given special stress to them as I think the matter is important enough to have earnest consideration.

My experience with crepe applies equally well to block rubber, as, generally speaking, it suffers from the same defects, namely loss of strength and nerve, accounted for by the fact that before being taken to the blocking presses the rubber is first treated by the creping machines.

Dealing with smoked biscuit or sheet as at present delivered to the market, my reasons for preference for the unsmoked is that for factory working the smoked offers no advantage, but on the contrary, the disadvantages are :—

1. Increased washing and drying loss.
2. Increased resin content.

the latter being especially undesirable when working against chemical specifications. I believe the general practice in operation is one where the smoking process is carried out subsequently to the coagulation of the latex by some previous treatment, and it is difficult to understand how this should recommend itself to manufacturers, as the smoking by these means is only more or less superficial, and no great advantage can be effected by subjecting the coagulated rubber to this process. If smoked rubber is to give a superior product over other methods of preparation, then I think the work must be carried out in such a way that the smoking effect is uniform throughout, and is not merely on the surface. If the treatment is beneficial at all, it is worth while conducting in such a manner that a homogenous product is obtained, taking hard fine Pará as an example where we have the smoking throughout. I have noted that recent processes have been devised to give effect to this, but I have not, up to the present, had an opportunity of examining the rubber so treated. I am not saying at this stage that smoked rubber is going to prove of greater value than unsmoked. At present I have quite an open mind on the subject. My suggestions are merely those for so effectively carrying out the process that we have to our hands a thoroughly smoked rubber which we can compare ; then it is possible that in the factory we may find additional advantages which at present are non-existent. My experience so far is that there is nothing to be gained by adopting this grade.

I would now like to leave aside the question of the class of plantation rubber and say a little about a matter which affects more or less all classes—a part of the preparation process which is near its initial stage, viz., the treatment of the latex. I profess no knowledge as to the actual operations, but the inference is obvious from the indications given in the manufacturing operations. I refer particularly to the matter of coagulating agents and antiseptics used at this stage. I am afraid that here again many of the plantations lose sight of the requirements of the manufacturing industry in that chemicals are used, the object being to get the maximum yield and best looking product without always bearing in mind the effect of these chemicals in subsequent manufacturing operations.

As an example of the ill-effect that might be produced by this practice without thorough trials and experiments, or without due consideration of the effect of excess quantities, I will mention particularly the effect on the manufacturing side from the employment of sodium bisulphite in the coagulating process, where, I believe, it is now extensively used as an antiseptic, and incidentally as a check to discolouration. The use of this chemical was, I believe, first introduced to the plantation industry by the Research Laboratory of the Rubber Growers' Association, after their chemical staff had thoroughly tested its properties, and satisfied themselves that no danger to the resultant rubber was to be feared. Possibly its application in very restricted quantities is quite harmless, especially if, in the subsequent treatment of the latex, the excess is removed; although on this point I think the question well worth further investigation. The employment of this salt was first brought to my notice in an indirect and peculiar way. We were manufacturing a line of goods to specification, where the sulphur content was to be adhered to strictly, and on samples of the goods being drawn the laboratory report gave an increased sulphur content. Operations were carefully checked and repeated, but still the sulphur content by analysis exceeded that of the mixing. Investigation of the analytical methods showed no error, and the crude that was employed was next examined, and sulphur being found present gave us the explanation.

On enquiry as to the reasons of this we found that sodium bisulphite was used for the reasons stated above, and consequently our Research and Experimental Departments were asked to look into the matter. From the examinations made so far it is surprising to find what a large percentage of the samples investigated contain sulphur, although, of course, other salts than the bisulphite may have been used. It has been noticed, however, that more vulcanisation difficulties in a general way have been met with from light coloured rubber than with the darker variety, and there is a tendency to preference in the factory, as a consequence, for the browner shades.

To test the effect upon vulcanisation of this salt, hard fine Pará free from bisulphite was taken and compared with the same delivery of rubber vulcanised with varying percentages of sodium bisulphite. The first series of experiments was based on a percentage of the bisulphite corresponding to the percentage calculated from the sulphur content we have found in the samples of unsmoked sheet, as delivered to the factory, which has been anything up to 0.25%, and in one case exceeding 0·5%, whilst in many the figure was well above the 0·25%. I do not propose to burden you with a long list of figures obtained from the experimental data, but a summary of the average figures is as follows:—Using up to 0·25% of sodium bisulphite, the stress is reduced about 20% and the strain reduced about 15%. In addition, the difficulties of completing vulcanisation are greatly enhanced, the addition of only 0·125% of bisulphite increasing the time of cure about 18%, and the addition of 0·25% increasing the time 27%.

In the second series of experiments the object was to ascertain the ultimate effect upon vulcanisation of additions of still further quantities of sodium bisulphite, as it appeared from the first series that the effects were considerable. In this latter investigation it was found that the addition of 3% of bisulphite was sufficient to prevent complete vulcanisation, and only a semi-cured, soft product could be obtained at the best.

It is obvious from these experiments that the employment of sodium bisulphite has a very detrimental effect upon the product obtained if the excess is left in the resultant rubber, and is possibly one of the factors at present responsible in some cases for variability in respect of the vulcanisation properties. There are indications that rubber is coming on to the market containing an excess of this chemical, which excess has not been removed in subsequent treatment of the latex. From the experiments I have mentioned, it is seen that a small variation in the percentage of bisulphite in the rubber being used in the factory will produce a very big variation in the vulcanisation heats required.

The percentage of bisulphite content left in the rubber may not only vary on different estates, but in all probability will vary in the deliveries from the same estate, where excess is being used, and this produces a condition of affairs that the manufacturer finds hard to deal with. In fact, variability of this nature is extremely difficult to handle, and considerable worry is attached to the vulcanisation problem as a result. In all probability the employment of other chemicals in the coagulating process has a material effect upon the after working of the rubber in the manufacturing industry, and this example will serve, I think, to illustrate my point that every consideration should be given on the plantation to changes that are made in preparing the rubber, always keeping in view the fact that other factors than simply the appearance of the rubber being turned out are worthy of attention. I would advocate a thorough trial and experiment upon the proposed changes before such changes are put into operation on a large scale.

Before leaving the question of variability, let me call attention to the practice among dealers of obliterating the estate marks from cases before delivering to the manufacturer. As the largest amount of rubber is purchased on type, and not as the product of any particular estate, a delivery to the factory may be made up of a collection of several estates, and under the conditions of purchase no one, of course, can object to this practice. Such a delivery, comprising the product of different estates, we know must increase the variability of the consignment. The estate marks having been removed, the manufacturer is not in the position unless the rubber itself is branded of being able to judge which estate suits his purpose best. Consequently, an estate producing a good grade of rubber is handicapped in that the manufacturer is not in a position to acquire this information from his deliveries. It is to the planter's interest, if he is producing a good quality of rubber, that his estate production should be known to the manufacturing trade and enquired for accordingly. I think it would be to the advantage of both the planting and the manufacturing industries if the rubber were delivered to the manufacturer with the estate marks intact. I am aware that opposition on this point will come from the dealers, and such questions as expense, etc., will at once present themselves. They should not be allowed to stand in the way if we really mean to eradicate the disadvantages from which this grade now suffers on the all-important question of variability.

I am afraid you will now be thinking I have a great deal more to say as to the defects than I have concerning the advantages of plantation rubber. I offer no excuse for this, for, whilst acknowledging the advantages, we are dealing with success so well established that at present, so far as we can see, there is every prospect of the position being maintained. Our efforts should now be given in those directions where plantation rubber at present has not yet succeeded in replacing other grades, and we should look to the prevailing defects that contribute to this failure, with the object of ultimately placing plantation rubber in the position that it can be used in place of any other grade on the market; the principal object being its equality with hard fine Pará. I know the aim of the plantation industry is to do this, and as a manufacturer I can assure you that we should be only too pleased to have this an accomplished fact. We are all keenly interested in the matter, and for this reason I have stated my experience, and indications as they have presented themselves from actual factory working.

Standardisation would also be an additional advantage to the manufacturer, but I would make an appeal under this heading not to effect too much standardisation of the faults as they exist to-day, but rather every effort should be given to the improvement of the rubber as it comes from the estates. In other words, although standardisation of plantation rubber to-day would considerably help matters, it is a mistake to imagine that with this accomplished, it would automatically place this grade on an equal footing with Pará. This will not take place, I am afraid, without due attention to the subject of estate methods where standardisation is initially required. Scientific control at this end of the operations will do much to bring about the object we have in view, and when that is achieved I think we shall find many of our troubles have disappeared, and we shall ultimately, I believe, get down to one class only of first latex plantation rubber, the properties and reliability of which we shall as readily understand as we do those of Pará to-day.

In leaving the subject I would make a request to our plantation friends, and that is for a closer working relationship between the two industries. Our interests are so much in common, it seems to me only natural that we should work together if progress is to be made, and plantation rubber brought to the final point of perfection. I think I might say that the plantation industry has to depend more upon the manufacturing industry than *vice versa,* for the object of the planters is to get manufacturers to use the rubber. We are not adverse to doing so, and the better the rubber the more we shall use. Organisation and experimental work should, I advocate, be conducted on the lines of co-operation with the manufacturing industry, if the best and quickest results are looked for. Speaking for The North British Rubber Company, Limited, we have always been willing to do our share in the matter by the help of our laboratories and experimental departments, and will continue to do so.

Up to the present, generally speaking there has existed what looks like a lack of confidence in the manufacturer, as invariably if samples are submitted for our opinion no information accompanies them in respect to the methods of preparation, etc. This is not just as it should be, for with full information at our disposal it is possible we might be able to offer suggestions, especially upon such points as the effects upon vulcanisation of the coagulating agents used. I have no doubt this lack of information is due, not to a feeling of reluctance in giving it, so much as to the inability of the home people, who themselves have received the sample from the estate simply for trial, without themselves being fully acquainted with all the facts. What we want is a closer relationship between the estate experimenting and the manufacturer, which might be organised, I suggest, by the Rubber Growers' Association as the most competent body to take this up for the benefit of both industries, whose one object is the placing on the market of plantation rubber which will give uniform results in the factory and reliability when put into use. That, I hope, will be an accomplished fact in the near future.

The CHAIRMAN : Those of us who have taken part in the conferences of the past six years have constantly heard the complaint from planters that the manufacturers did not tell them what they wanted. No one can say that now. We have listened this morning to a full, clear and definite statement of what the manufacturers desire in regard to rubber and what they do not desire. I regret that there are not more planters here this morning, but probably those who are here will give a good account of themselves. The only point to which I wish to draw attention particularly is the question of the mechanical working of plantation rubber on the plantations before it comes to the market. This question of variability has been in the air more or less ever since plantation rubber came along. If ever any figures have been published that sought to prove that there was a definite effect due to the age of the trees and so on they have been either inconclusive or negative. On the other hand, in this mechanical working we have an effect that those of us who handle rubber understand fully.

Mr. WICKHAM : The point that always impresses me as an extraordinary thing is that Para rubber has never been made in the East. It is perfectly easy to make, but what they have done is to evolve an entirely new industry based on fundamentally different lines. Of course, all the gentlemen here who are connected with rubber understand that you cannot make Para rubber out of coagulated latex. The whole of the plantation industry as evolved in the East is founded on coagulation. They get a reaction by solution or otherwise, or by natural coagulation, and then the rubber is milled and put through the various processes. That results in what we call plantation rubber. In South America, of course, if you get coagulated latex you cannot make Para rubber. The coagulated rubber has to be squeezed out and passed on as Sernamby, or negroheads. Para rubber can only be made from the latex straight from the tree, and any indication of coagulation immediately prevents your making it. You must get your blast contact with the antiseptic cure, and that immediately sets up the film that prevents coagulation. The chief trouble in actual working in South America is that you cannot get through your material without a large amount of coagulation taking place ; approximately about one-third of the day's takings will be hard cured. The other latex becomes more or less coagulated and has to be set aside to be used in another form. It is certainly extraordinary that in the East they have not tried to get some of their rubber without coagulation. I can see no reason why it should not be tried. You can have your plantation rubber and your Para rubber both made in the East, and manufacturers can take whichever they prefer.

Dr. STEVENS : I have on previous occasions put forward certain criticism of Mr. William's statements, and it is a little too warm to day to go over them again, but I will put one or two points as shortly as possible. In the first place I plead for a more accurate definition of what Mr. Williams describes as " average plantation rubber " and what he describes as " Para." Does he refer merely to up-river Fine Hard Para, or to all varieties of rubbers, including scrap ? So much depends upon the definition of those terms. Of course, I think he is quite on the right track in pointing to the fact that we should have more uniform methods on estates than at present. There is no earthly reason why they should not be adopted. I am quite certain that much of the variation arises from the different methods in the treatment and preparation of rubber. With regard to the variation of crepe, when a manufacturer gets a crepe rubber he is not always prepared to say whether it is prepared from latex by coagulation and washing or whether it is a scrap crepe. There are some of those scrap crepes which, after being carefully washed, are indistinguishable from first latex crepe. If it were only possible to label these crepes, I think manufacturers would find that there would be much less variation than previously. I quite appreciate Mr. Williams's remarks in two instances, the first being when he says that the pretty appearance of rubber is of no importance to the manufacturer. The reason the plantations turned out their pretty crepes was simply because they fetched a higher price. There is not much in it now, but a year or two back the difference in price was very considerable indeed. The same thing applies, to some extent, with regard to smoked and unsmoked sheets. I also quite appreciate the point about the higher resinous content of smoked sheet making it more difficult in working against chemical specifications for manufacturers, but there is one statement I should like to take exception to, and that is that the smoking of sheets is superficial. The smoke penetrates right to the centre of the sheet, although it is more on the outer layers than in the inner layers. You can see this by simply immersing the smoked sheet in benzine. Now I come to the vexed question about sodium bisulphite; as I was largely responsible for its introduction, I must defend it. I have pointed out to Mr. Williams already that it is not fair to mix sodium bisulphite with the rubber in his experiments, as that is a very different thing to putting a trace of it in the latex. Of course, I have seen references to it as if it was a bleaching agent, but it is not that. It merely restrains the action of the enzymes. The quantities used are much smaller than Mr. Williams thinks, and they do not do any harm. I have vulcanised samples which have been put by for some years after this treatment, and I have found that there is no change, or any trace of decomposition. One other minor point I would like to make is that I agree with Mr. Williams with regard to the view that the stress and strain tests should be backed up by other tests. As a general guide they are very good, but in some cases they are not sufficient.

Mr. WILLIAMS: As to what I class as Para rubber, the kind that I mean when speaking of the grade we hope the plantations will reach is finest up river Para. When I speak of average plantation rubber, what I mean is average deliveries of first latex and plantation sheet. In reference to what Dr. Stevens has said concerning the style of preparation, I quite appreciate his point of view and the plantation point of view. It is only natural that they are going to make the rubber which will get the higher prices. But I think we have only been paying the higher prices because our eyes were not widely enough opened as to which was the best rubber to suit us. That applies both to crepe and to smoked sheet. Coming to the vexed question of sodium bisulphite, I do not speak of the presence of sulphur with surprise, as Dr. Stevens seems to think, and I do not agree that in natural rubber you get 0·1 of sulphur, which in a good many samples we have found. Dr. Stevens knows that once an excess of a chemical is added to a rubber, it is extremely difficult to get it out, even by washing. In fact, it is almost impossible. The tenacity with which rubber holds on to certain chemicals is remarkable. We find it so with ordinary alkalies. The matter requires further investigation in that respect. I rather fear that on the plantations the chemicals are not added in the quantities laid down, and when these excesses are added they remain there.

Mr. P. J. Burgess: I think we may say that this paper is an indictment of plantation rubber for being variable, it being taken by the author that all the troubles in his and other factories are due to variability. Without going very far into the causes of this variability, I may say there are two broad ones, the natural and the artificial, some within the control and some outside the control of the planter. How are we going to get rid of this variability? Is it possible or practicable at the present time to hope for any agreement among the 500 or 600 or 700 companies all responsible for carrying out their share of the plantation rubber production? I think it is impossible to hope for the establishment of a uniform system; that is the position we have to accept. Rubber will still come forward in all the shapes and forms that we see at present, and we have to get over the practical disadvantage of this. I do not think the producers are the only ones who are to be held responsible for this variability, for I think there must be a variability in the demand as well—in the preferences, that is to say, of those who use the rubber. How can we get over the practical disadvantages arising from variability, if that itself cannot be obviated? We can only give out that we are selling the rubber without knowing the variability, or else the alternative is to find out what the variability is before we sell the rubber. The position is so clear to me that I fail to appreciate the practical difficulty of finding out what we are selling, and then selling it. The paper shows the difficulties the manufacturers are suffering under at present, but there is one other little point I would like to mention, and that is the problem of tracing the variability back under present conditions. Mr. Williams tells us that he gets his batch of rubber and then puts it through his own testing department and grades it. Well, this grading is for the people in the factories alone, and the information which has been obtained is never sent back again to the producers. The producer never knows what the result of his rubber has been. Directly the rubber has been sold, a big blanket is let down, shutting out its subsequent history. I would like to ask Mr. Williams whether in those instances in which the rubber is stamped he ever does take any step to indicate the faults or the qualities to those who have produced it? We must get more touch between the producers and the actual users, and we must lift this veil which drops between the two.

Mr. Gibson: I made the point at a previous meeting of the Congress, but would like to emphasise it now, that it would be more to the interest of the plantation industry if we sent out to the East as research chemists young factory chemists who, already having had good experience in the working of rubber, would know what they were really after, and would produce better results than newly fledged scientists. I make this remark without any reference to the gentlemen already sent out. In Mr. Morgan's book on plantation rubber comparisons are made between Fine Hard Para and plantation rubber. Some of you know that my sympathies are with plantation rubber, so that I am not getting up as an opponent of it, but as a candid friend. After reading that book the impression I formed was that it was considered desirable to give plantation rubber the benefit of some window dressing. If the comparisons between plantation and Fine Hard Para are really not such as we find in the book, those interested in the plantation industry will be deceived, but the manufacturers will not be deceived. Manufacturers can see for themselves, but the people on the plantations have not got the direct opportunity of forming conclusions. and therefore they rely on the statements in a book such as this. One of the points the manufacturers would not like is that so few samples of Fine Hard Para are taken for consideration, and no clear information is given that samples have been chosen by disinterested people. Then we are not told the methods of testing. I think that in any future communication coming from the Rubber Growers' Association we should be told exactly what methods are being used, for it cannot do any good in the minds of the manufacturers if details of the work are not given. They are sure to form wrong impressions. One point with regard to the testing is very unsatisfactory. We are given a new definition of resilience and are not told how the factor is found out. When comparisons are made between plantation rubber and Fine Hard Para, we are entitled to be given all the methods by which results are arrived at.

Some Aspects of Plantation Rubber.

By

E. L. KILLICK.

Dr. Torrey presided, and in Mr. Killick's absence the paper was read by Mr. Baxendale.

Recognising as I do that nothing like finality has yet been reached in our knowledge of plantation rubber, my object in this brief paper is rather to stimulate discussion than to lay down the law. In the earlier days, when little was known on the subject, dogmatism was rife. Subsequent experience, however, has had a very chastening effect. Nearly all preconceived ideas have gone by the board, and to-day we find that those who know most about plantation rubber are the least assertive in recording their views and experience. I yield to none in my respect for and admiration of the scientist and his work, yet it has ever been my humble opinion that, had this particular industry received less attention from science at the outset and been allowed to develop along lines dictated by common sense and experience in practice plantation rubber would have been the better for it. Whilst anything in the nature of rule-of-thumb methods must always give way to the enlightened teaching of science, I submit that there is a period in every industry when the intervention of the latter may be premature and apt to retard rather than to promote its well-being. Plantation rubber is a case in point. In the very beginning of the industry science assumed control and dictated to the planters what they should do. The planter submitted to his autocratic mentor, and having embarked upon a certain course found it increasingly difficult as time went on to turn back and leave the beaten track. We have a product that is theoretically the best rubber produced, but it is what I can only describe as over-civilised. It lacks the nerve and strength of its uncultivated rivals. By devious and intricate paths science has brought us into a veritable maze, the key to which has yet to be found. The industry is now faced with two alternatives—either to retrace its steps or trust to science to lead it into the right path. Is the entire system of rubber manufacture to be revolutionised, or will the scientist take the product as it is and transform it by the operation of some magic formula into the perfect raw material? These are questions that are being asked in the industry to-day.

In the first stage of plantation rubber production we are apparently at fault. The fundamental difference between Para and plantation rubber is that the latter in the first instance is cured by the agency of smoke, whereas in the other it is coagulated by acetic acid. Dr. Schidrowitz has, I think, demonstrated that the less acid used in the preparation of plantation rubber the better the product. It may, therefore, be assumed that if the acid process were entirely eliminated plantation rubber would be still further improved. May we take it then that at some future date the present system of coagulation will be superseded by a more innocuous method ? If scientific research has been conducted on these lines it has been singularly unproductive, for no alternative method has yet been forthcoming that has found favour with the planting community as a whole. Coagulation by an acid admixture has the advantage of being prompt as well as cleanly, whilst the esteem in which plantation rubber is now held by manufacturers proves that the harm said to be wrought by the acid cannot be very great. On the other hand it may well be that the variability displayed by the cultivated product is indirectly due to this process, inasmuch as no hard and fast rule is followed as to the strength of the coagulant. I think the suggestion has been made during the conference that an alternative method might be found in a system of rapid evaporation of the water in the latex. On the face of it this appears an excellent suggestion, worthy of closer consideration. But here again we come across one of the many baffling anomalies that exist in connection with plantation rubber. For example, it might be thought that no superior and no more uniform rubber could be found than tree scrap and that grade which consists of rubber produced by the unaided coagulation of the latex before its arrival at the estate factory. Yet the consumer relegates it to a secondary place in the market by paying more for rubber that has been artificially coagulated. Possibly this grade of rubber stands at a discount because the limited supply does not allow of its extensive use. There is reason to believe that the manufacturer prizes uniformity in the raw material above everything else, so that, if this matter of variability can be obviated without an entire change of the methods commonly adopted on the plantations, it seems highly probable that the system of acetic acid coagulation will remain, in other words that the consumer will be content to take the product as it is provided it carries with it a guarantee as to its behaviour under vulcanisation. Efforts are now being made to render this possible. In the event of a successful issue the chief complaint of the manufacturers will be removed.

Not the least surprising development in the raw rubber market is the high repute attained by smoked sheet. Seeing that the smoking in this instance is quite superficial, the advantages of the process are far from obvious. Not only is the rubber discoloured by smoking, but additional washing is necessary in the consumer's factory. According to the experience of Mr. W. A. Williams of the North British Rubber Co. the manufacturer has nothing to gain by adopting this grade. His view is that unsmoked sheet or biscuits give the best general results, the disadvantages of smoked rubber being increased washing and drying loss and increased resin content. Logically there is nothing to be said in favour of a mere surface smoking such as plantation rubber receives unless it be that the smoke acts as a preservative. But as there is so much that is illogical in respect of plantation rubber this contention must be set aside. It would, however, scarcely occasion surprise if the smoking of rubber as now carried out in the Middle East were to fall into disuse. The view of the Conference on this subject would be of interest, if only because the question has a certain bearing, if slight, upon the cost of production.

On the subject of producing costs, also, my remarks must be rather interrogative than informative. Investors would greatly appreciate reliable evidence as to what the ultimate cost of producing rubber will be on an average plantation. It has been said that there is no obvious reason why the cultivated product should not eventually be turned out at a cost approximating to that of tea. If this be so then the investor has much to be thankful for. One recognises that there is a very great deal in Dr. Lock's advice as to seed selection, for it is obvious that, if by such means only the most prolific producers are retained for cultivation, the larger yield per acre would make the cost of production per unit appreciably less. But this is admittedly a question the significance of which is somewhat remote. Fewer trees to the acre and less frequent tappings may provide the means by which working costs may be considerably reduced. Experiments have shown that frequency of tapping has little bearing upon aggregate yield, for according to a Ceylon authority, trees tapped once in seven days have given as much rubber as others of similar age tapped daily. Nor can it be said that fewer trees to the acre involve a reduced crop of rubber. If, in addition to these modifications the ordinary factory process be simplified—as there is reason to anticipate—the average cost of producing plantation rubber will certainly be reduced. Costs are largely governed by selling prices and it is tolerably certain that if the price of the commodity had never exceeded the present level, the plantations would now be operating on a much more favourable basis.

The old fallacy that 'the plantation industry is not cultivating the true *Hevea* was recently revived. The late Dr. Huber, after an extensive tour of the plantation zone, not only recorded in his report that the tree cultivated in the East is the true *Hevea*, but made an emphatic statement in public on more than one occasion to the same effect. If plantation rubber be in any respect inferior to the wild variety it is certainly not due to any fundamental difference between the *Hevea* of Brazil and that of the Orient.

As regards the financial aspect of plantation rubber, the situation is so involved and the future so dependent upon certain contingencies that it is impossible to speak with any degree of certainty about the outlook. Should the commodity improve in price or even remain stationary, the majority of the existing companies should ultimately give a good account of themselves. On the other hand, a further fall to the neighbourhood of eighteen pence would at this juncture be disastrous to many immature plantations whose capital resources are exhausted. Very many companies must rely upon the revenue derived from the crops from their bearing areas for the upkeep of their immature fields. In the event of such revenue being cut off by a further slump in the commodity the position of these companies will become desperate. Mortgagees may foreclose, and many of the smaller companies will doubtless be absorbed by the large and prosperous groups. The prospects of the industry are sufficiently good to justify reconstruction schemes in many instances, but whether in the event of lower commodity prices the public will be disposed to provide the necessary additional capital in every case is open to doubt. Evidence will have to be provided that such properties are in good order and capable of being brought to a profit-carrying stage within a reasonable time and at moderate cost. Failing this, reconstruction proposals will find little support, and in the end we may take it that many quite hopeful properties will be acquired by one or another group on exceptionally favourable terms. Obviously those companies that have conserved their resources will be in the best position. It does not seem probable, however, that many plantations will actually become derelict. The industry is too well established, and one might say, too profitable to admit of such a contingency. On the other hand it may well be that, through lack of funds, individual estates may revert to such a weedy condition as to depreciate enormously their value. Such estates will be in the market at the price of an old song, and will doubtless be readily acquired by trust companies and the like. In the end it would seem that the plantation industry will be capitalized on a considerably lower basis all round, so that reasonable profits will be earned, even with rubber selling at a very low price.

There is, however, another and a more cheerful aspect, namely the position in the event of an upward movement in the price of rubber. This, by the way, is a possibility with which the industry is always confronted. By some, such a contingency is viewed with pious horror. Nevertheless, it is a reasonable possibility. Some new outlet for rubber may come into operation at any time, and so increase the demand as to put up prices substantially. It will be admitted that the rubber-capped wood paving, of which a specimen is seen in this building, has immense possibilities in this respect. If a considerable section of roadway were laid with rubber paving in a populous district of London and proved as superior to every other material as its sponsors appear justified in believing, who would be bold enough to say the price of the commodity would be unaffected? Those who are doing all in their power to increase the use of plantation rubber may unwittingly bring agencies into being with results entirely unforseen and possibly undesired. I think it is a fair assumption that, but for the desire of certain large plantation interests ostensibly to freeze out wild rubber, or, in reality, to drive out of business some of the struggling plantation companies with a view to acquiring their estates at bargain rates, the price of the commodity would never have fallen to its present level. But this narrow and selfish policy may well defeat itself. The time will come when the sum total of wild rubber will make a very poor showing against the outturn by the plantations, and when the matter of a few thousand tons more or less will be but a negligible quantity. If there be anything in the new uses for rubber indicated at the Exhibition—and few will deny that their potentialities are very great—then not only will there be a keen demand for all the rubber the world can produce, but a maintenance of prices at a highly remunerative level.

The CHAIRMAN: As to the contents of this paper, it deals with a very wide range of subjects, and probably we will not all find ourselves in entire agreement with some of the views expressed by the author.

Mr. BAXENDALE: Mr. Killick says that "experiments have shown that frequency of tapping has little bearing upon aggregate yield, for trees tapped once in seven days have given as much rubber as others of similar age tapped daily." I hardly agree with that. The most we have arrived at is that a tree tapped once in seven days yields possibly more than if tapped every day, but so far as we have gone there is a decided advantage in daily or alternate day tapping. My experience is that taking alternate days we lose about 25 per cent. in production, but the wage bill is only half as much, so that possibly it pays better than the every day tapping. I believe that in a year or two the alternate day tapping will yield practically the same as the every day tapping, but while the trees are getting used to the change you lose rubber. I do not suppose anyone of us would object to seven days tapping if results were going to be the same. We would have the felicitous experience of paying next to nothing for labour.

M. LEPLAE: I do not think I can have rightly understood the reference to seven day tapping. It would be interesting to know on what experience it is advocated, and whether anything like the same quantity of latex has been obtained.

Bonus Schemes for Managers and Assistants on Plantation Rubber Estates.

By

P. J. BURGESS.

When I chose the consideration of bonus schemes as the subject matter for this paper, I knew that I had chosen a dull subject, and the hope of being useful rather than amusing was in my mind when I wrote it. I can only trust that the lack of general interest will be to some extent compensated for by the special interest which the subject must have for all those who control the administration of rubber estates, for those who are happy enough to receive the bonus, and the shareholders who are nowadays happy if they are able to give any, and who can always add to their satisfaction in giving it by remembering that their function is proverbially the more blessed.

Under the head of " Bonus " I propose to include commissions and all similar payments which vary from year to year, and which are not included in the terms " Salary " and " Allowances."

Looking at the subject broadly there appear to be two distinct schools of thought :

a. That in which the bonus is an extra reward given for special efforts, or in special circumstances.

b. That in which the bonus is more of a deferred salary, and is often made an excuse for keeping salaries low.

The correct function of a bonus, I think you will all agree, should be a double one : it should reward effort, and stir up gratitude of the kind which has been defined " as a lively sense of benefits to come " ; and the dual function should be so adjusted that the effort and the bonus become largely cause and effect, and the recipient of the bonus be made to recognise this by the form that the bonus takes.

The ideal bonus should also serve many other purposes, which I now propose to try to indicate to you, then to see how far various existing schemes satisfy the ideal conditions, and finally to present for your destructive criticism my effort at solving the problem of the construction of an ideal bonus scheme.

Objects to be Attained by a Bonus Scheme.

a. The first and essential object to be attained is to give the management a financial interest in the results of the work, and in this way to bind up the interests of the men on the estates with those of the shareholders or owners.

b. The second function of a bonus is one which is most frequently violated in modern bonus schemes. The bonus should be earned when, and only when, special effort on the part of the management is shewn. It ought to be accepted as an axiom that the ordinary routine management is amply paid for by the ordinary salaries. The mere fact of large profits being earned is in itself no basis for any bonus claims ; such profits are the reward of capital which has earned them through accepting exceptional risks or through the foresight with which it has been employed. As soon as this qualification for receiving a bonus is recognised, the very valuable quality of the bonus as a stimulant to the management is brought out, and no scheme can be considered a good one which does not respond satisfactorily to the test of being a stimulant.

c. The scheme should apply to the whole of the estate management, and not only to the few heads. If it is possible, I should like to see the native staff included in the scheme, but whether this be practicable or not must depend upon local circumstances. In any case, however, the whole of the European staff should be included in the scheme, and such inclusion should go far towards preventing toleration by the staff of incompetent or lazy units in their body. The feeling that slackness by any one of them would result directly in financial loss to the rest, and not merely to some nebulous corporation or owner, would tend to imbue the whole with keenness and the sense of being a "team" which gives the finest results. At cricket, football, or in business this is the right feeling.

d. Continuity of management should be developed by a suitably chosen scheme, and continuity of association with the same estate or group of estates, should be an essential qualification for the receipt of any bonus. The fact that there must of necessity be some lapse of time between earning and receiving any bonus payment would act as a deterrent to the staff frivolously, or in moments of irritation, throwing up their appointments. In this respect a bonus scheme would have the same stabilising effects as a pension scheme, but in a less degree.

e. In so far as continuity of management is fostered, so will the authority and control of the direction over the local management be strengthened. In this way the bonus scheme very materially assists the supreme control.

f. Any scheme which is put into force should be easily understood, and as simple as possible. The amounts due to the staff under it should be readily calculated from published accounts, and afford little opportunity for disputes. When the scheme has been settled, it ought not to be possible for the supreme direction to materially vary the conditions for the current year, or to regulate the amount earned under the scheme by their own actions. To make this point clear, I may take as an example the bonus which is made to depend entirely upon the rate of dividend paid on the year's working. It is clearly quite unfair to the staff, whose work might have been in every way excellent, to compel them to forego a bonus when very large profits may have been earned, simply because those profits are put back into the business as extra capital, instead of being distributed as dividend.

The staff can have no voice in the manner in which the profits are dealt with, and it is therefore reasonable to say that their bonus should be independent of any such manner of dealing.

g. Local uniformity of system is a very valuable quality for any bonus scheme to possess, though the present condition of the rubber growing industry does not justify any hope of agreement about this or any other really important matter. The nearest approach to any uniformity of system is to the credit of the Dutch in Java and Sumatra, and in that case it is a relic of systems in force for other products before rubber came into the field.

h. It is quite a good feature for a bonus scheme to possess a "sporting" element of chance about it. Managers and assistants are good sportsmen, and the price of rubber as it affects the bonus affords all the "flutter" that is necessary.

VARIOUS EXISTING SCHEMES.

In nearly every instance the principle of "no profits, no bonus" seems to have been adopted, and accepted equally by those who pay and those who receive. An attempt has been made in some cases, however, to stimulate work by bonus when profits are not in sight, as in the case of paying commissions on areas as they are planted, a rupee per acre in Ceylon or a dollar an acre in Malaya. Such commissions are rather special, and practically only existed during the boom conditions of 1910 and 1911.

In Java "picul money" on coffee, a bonus of 20 to 40 cents on each picul of coffee made, has been often paid to the junior staff, while the managers have had a bonus under another system.

Both the above instances violate the conditions I have already laid down, in that they do not depend entirely upon special effort. Work for which the management should properly be dismissed would instead be rewarded with a bonus, if a single acre were planted or a picul of crop prepared.

It is, however, when profits are earned that "bonus" is expected, and though there is no logical reason why special work should not be specially rewarded in the early days of a plantation's history, the human psychology of the situation allows the distinction to be made.

Rubber growing is a young industry, and, as is natural, the bonus schemes which have been applied are those that are simple and most obvious, and are mostly of the "percentage of profit" type. Sometimes only the head management participates, often all the European staff has a share, graduated according to seniority, importance, and merit. In the early days commissions were given on such a lavish percentage that the bonus amounted to many times the salary when the profits from the high price of rubber were exceptional. A usual percentage now is 2½ per cent. of the profits, to be distributed among the whole staff in various proportions.

At first sight it would seem that this is a scheme which should stimulate to effort, but a little further reflection will shew that under past and present prices for rubber there is such a considerable profit from any estate which is at least eight years old that average or even poor management will shew some profit, and under such a simple scheme a bonus would be paid when it would not be deserved. Unearned bounty stifles instead of stimulates effort. It is not possible to come to any conclusion other than that a bonus scheme depending solely upon a profit being earned is unsound, if,

a. the salaries paid for management are fair and reasonable,

b. economic conditions are such that poor management can earn a profit.

When "profit" is the basis for calculating bonus, "profit" needs definition, and in Dutch, as compared with English systems, the word has a very different significance.

The Dutch consider that an estate earns a profit when the total receipts exceed the total expenditure, and the discrimination between "capital" and "revenue" expenditure which is always made with English accounts is not made with Dutch accounts when calculating the "profit" for bonus. This Dutch method, which is financially irrational, dates from the time of sugar, coffee and tobacco, and all the mixed cultivations so favoured in Java.

Sugar and tobacco being annual plantings, were revenue producing from the start, and the Dutch system was suited to them, though it is not suited to rubber.

A system of bonus has been largely adopted in Malacca by which the normal salaries of the managers and assistants are increased by a percentage equal to the percentage dividend paid on the share capital of the company. This has the merits of simplicity and of being clearly defined. It suffers from the same defect as the system of bonus by a percentage of profit, and also, as I have previously explained, from the grave objection that the bonus for the work done is made dependent upon the mode of employment of the profits. To take a very simple illustration in the case of a company whose shares were, let us assume, only partly paid up. It might be decided that instead of calling up the balance of the uncalled capital for normal development or perhaps extension, the profits earned should be appropriated for this purpose, and dividends not distributed. This might be sound finance, but it would react harshly upon the staff, who would lose their bonus.

Another method which has been more used by private owners than by companies, is what may be called the " Paternal System," in which there is no prearranged contract or obligation to give any bonus whatever, but something is given if it is felt that it is deserved.

Nothing could be better if all owners were angels and boards of directors divine. With human nature as it is, and many thousands of miles separating estate owners from their managers, I fear this method would be more often either unjust, or philanthropically lavish, than fair and reasonable.

A Suggested Scheme.

Keeping in mind the ideals which have been elaborated, I now propose to attempt to evolve a scheme which will satisfy, and at the same time be practical and fair to both sides.

I shall deal first with the case of an estate in bearing, but will shew how the ideas underlying the scheme may be as easily applied to the development stage as to that of production.

It will, I consider, be of assistance if an imaginary case be taken, and the scheme worked out in reference to that, preferably to all the time with indefinite quantities.

I therefore suggest that we imagine an estate in Malaya of 1,000 acres of rubber ranging from 4 to 7 years old, from which a crop of 200,000 lbs. is to be harvested during the year under review.

The estate is supposed to be in fair order and to have an ample staff of Europeans and sufficient labour.

It is presumed that a reasonable profit will be made on the year's working, and it is from this profit that the bonus will be paid. It is assumed that the capital fund is exhausted, and that all charges will be carried by the crop ; and that the necessary buildings and machinery have been provided.

The first condition of financially interesting the staff in the success of the estate is satisfied by paying a bonus, as will be evident.

The second condition of making the bonus depend upon special effort is the critical and difficult one to satisfy. I propose that some regular representative work on the estate be focussed in the attention of the directorate; in this case the obvious work should be the cost of harvesting the crop. This cost must be the "all in" estate cost, free on board for export. It includes the whole of the expenditure on the estate, the values of stores imported by the estate, and any other estate charges of which the local management has any control.

The directorate will form an opinion of what this cost per pound of rubber should fairly and reasonably be, having due regard to all the individual circumstances of the estate, the locality, age of the trees, soil and climatic conditions, labour costs, and all the factors which must be within its knowledge. With the average estate I am supposing, this cost may for illustration be put at 1s. 6d. per lb., and it is then taken as an axiom that unless the management can do better than this ordinary work, it is not entitled to any bonus whatever. The work of mediocrity which 1s. 6d. per lb. implies is taken as the work for which the regular salaries are paid, and the profit, if any, earned by such work is entirely the reward of capital.

For each penny per lb. at which the crop is produced below this mediocrity cost of 1s. 6d. a certain percentage of the profit should go to the management as a bonus, say ½ per cent. for each penny. Thus if the crop were produced at 1s. 5d., the bonus for distribution would be ½ per cent. of the total profits; if at 1s. 4d., the bonus would be 1 per cent.; if at 1s. 3d., the bonus would be 1½ per cent. of the profits, and so on. In this way, while the profits grew larger, the percentage that the management would draw would become larger, and the saving of a penny in costs from, say, 1s. 1d. to 1s. per lb. would bring a bigger increase in bonus than a saving of a penny in reducing the costs from 1s. 6d. to 1s. 5d. The difficulty in making the final reduction is much greater than in making the initial reductions, and in this way the reward is proportioned to the effort. This progressive value of each penny saved should afford a satisfactory stimulus to continuous effort to do still better on the part of the management.

I have drawn up a table shewing in actual figures what the gross profits and the bonus on them would be under various conditions of sale price and cost of production, and attach it as Appendix "A" to this paper.

The "Sporting Element" in the bonus would be fulfilled by the profits being the fund from which the bonus is drawn.

The bonus scheme should be clearly explained to the management, and the conditions under which it would be operative should be defined by a set of rules, which would embody the remaining ideals with which we started.

Without actually drafting these rules, it may be of interest to indicate the specific points they ought to cover. In the first place the annual published accounts should be the authority for the figures used in calculations, and the auditor's certificate would guarantee their accuracy.

The bonus should be divisable between the staff in some definitely arranged proportion, which in my own view should approximately follow the rates of salaries, with a special share for the manager, as having a degree of responsibility greater than that indicated by his salary.

The bonus scheme should be in force for only a year at a time, and the basis of it would be revised each year. This is quite necessary if the underlying principle is to be maintained, on account of the normal cost of harvesting becoming reduced by the growth of the trees, and being liable to variation from numerous causes over which the local management may have no effective control.

It should be a condition that the bonus is only payable to members of the staff who are still in the employment of the company when the bonus is declared. This tends to ensure continuity of management, but also makes it necessary to remove any temptation to capricious dismissal of subordinates, by making it a rule that when the establishment has been settled for the year any shares in the bonus which become forfeit cannot be divided among the rest of the staff. Neither should such shares revert to the company, but should, I think, go into a "sick" or benevolent fund established for the benefit of the staff and administered by the directorate.

Whenever an employee has an opportunity of increasing a fixed salary by extra work or by other means, there must always be a force at work tending to make him concentrate upon the extra variable source of income, to the detriment of the work or duties for which the fixed salary is paid.

All existing bonus schemes have this element in it, and the danger is not absent in the scheme I have put forward.

The attempt to attain the cheapest possible working may lead the management to attempt economies which are false, to postpone repairs to lines, roads, machinery, and so on, especially at the close of a financial year. In view of this the services of the visiting agent should be specially of value, and he should be asked to give his particular attention at the close of the year to any possible deterioration in the general condition of any and all of the features of the estate.

By making the bonus deferred, the continuity of management would tend to check this evil also, and it is another reason for making the bonus only payable when the accounts have been passed, and then only to those still in employment.

The system I have outlined provides its own automatic checks upon overtapping or undertapping; the former would raise the costs, the latter would decrease the total profit, and that condition which gives the best bonus results will be found to give the best gross profits results also. It does, in fact, make it pay the staff to get the most at the cheapest rate.

In the case of an estate which is in process of development the same principle can be used as basis for a bonus, and the only difficulty is to find some representative work, which is as definite an indication of zeal as is the cost of harvesting rubber.

The same degree of critical attention has not been paid to the development of estates as is now being paid to the working of them, there has not been the same wealth of figures for comparison, and the years of development have been in general years of plenty, when money was to be had for the asking, and shareholders were as full of hope as their pockets were of cash.

A knowledgable Board should, however, be able to settle upon a standard work, such as the weeding and general upkeep of the estate, and with a statement from the visiting agent at the close of each year as to the condition of the property, the cost of this work might be taken as the basis for bonus.

Thus if $1 per acre per month be taken as the fair weeding and upkeep figure for a certain estate, it might be arranged to give a bonus of 1 per cent. of the salary for each 2 per cent. of saving, assuming that the salaries will come to about $1 per acre monthly. As the basis for the bonus became narrowed so it would become more necessary to closely scrutinise the rest of the estate costs, to prevent any neglect of one work which does not affect the bonus for another work that does.

I have, however, I consider, said enough to shew the lines on which a bonus scheme should be developed, to be fair to all and an incentive to the best that estate management can do. There are many points of detail which will no doubt present themselves to you, but as I have been writing with an expert audience in my mind, I am content to present the ideas in the paper as they stand, and leave further elaboration of detail to any who may propose to adopt the general principle I have developed.

APPENDIX A.

Scale shewing the profits and cash value of the bonus calculated on an assumed output of 200,000 lbs. of rubber, harvested and sold at varying prices. Fractions of £1 have been disregarded.

"All in" cost of rubber per lb. on the estate.	Percentage of net profit given as bonus.	Average sale price of rubber for the year after deducting freight sale charges and expenses off the estate.					
		1/6		2/-		2/6	
		Gross profit.	Amount of bonus.	Gross profit.	Amount of Bonus.	Gross profit.	Amount of Bonus.
		£	£	£	£	£	£
1/6	—	—	—	5,000	—	10,000	—
1/5	½	833	4	5,833	29	10,833	54
1/4	1	1,666	16	6,666	66	11,666	116
1/3	1½	2,500	37	7,500	112	12,500	187
1/2	2	3,333	66	8,333	166	13,333	266
1/1	2½	4,166	104	9,166	228	14,166	353
1/-	3	5,000	150	10,000	300	15,000	450
/11	3½	5,833	204	10,833	379	15,833	554
/10	4	6,666	266	11,666	466	16,666	666
-/9	4½	7,500	337	12,500	562	17,500	787
-/8	5	8,333	416	13,333	666	18,333	916

It will be noted from the above that the increase in the bonus is an advancing one for each successive penny reduction of costs, without unduly trenching on the increase in the profits.

The CHAIRMAN: This is a subject with which we who are manufacturers are, of course, familiar. The difficulty in connection with bonus systems is to find a proper level for the start, and to decide on what is a fair rate of bonus and on what basis it is to be allotted. There are some respects in which it should be easier on a plantation than in a factory to fix up your scheme, because in a factory some branches of the work are quite independent of other work. Not all the workers may be said to have such a hand in the success of operations that they should share equally in a bonus scheme, but those who do not benefit, or who benefit less than others, may feel that they have cause to complain.

Mr. JOHN MCEWAN: I think this paper by Mr. Burgess will be a very useful one for those who have not yet considered the question, and want something to go upon. He has told us that there is an infinite variety of circumstances and conditions, and directors of companies and those responsible for the management of estates must be in a position to know what to do. It will be perfectly impossible to lay down a hard and fast rule applicable to any estate. The merit of this paper is that it makes a variety of suggestions. In connection with tropical agriculture I think any general application of the system of giving bonuses is very modern. It came in with rubber, and not even at the beginning of rubber. It certainly did not apply to any extent to tea plantations or the older plantations in the tropics, and most of the additions to the earnings of the estate staffs were, in pre-rubber days, in the form of supplements. We are indebted to Mr. Burgess for the sake of those who have not in past experience been able to initiate a bonus scheme. From the very nature of things it is impossible, of course, to have a uniform system of bonuses applicable to all estates, but this ought to serve well as a guide. I agree that the man who does the actual work on the estate, and his assistants, should get every possible encouragement from those who sit in armchairs at home and try to direct things they very often know very little about.

Rubber Production Costs.

By

CYRIL BAXENDALE.

On the invitation of the Chairman (Dr. Torrey), Mr. John McEwan, Chairman of the Rubber Growers' Association, and one of the Vice-Chairmen of the Congress, presided at the reading of this paper.

Mr. McEwan: I am sorry to displace such a competent President as Dr. Torrey. He is absolutely as fully qualified as I can be to take the chair while this brief paper is read on a subject of very much interest to all those concerned in the growth and production of rubber. I do not want to in any way anticipate what is going to be said by Mr. Baxendale, but I would say this in connection with costs. A few weeks ago I was called into conference about a very extensive manufacturing business and plant not far from where we are now. The business had been in existence for more than a century, and was in the depths of distress with its debenture holders, mortgagees, etc. The question was whether, for the sake of the staff of fourteen hundred men and women, it could be continued. I made investigation with regard to the building, plant, staff and accounts and so on, and then interviewed the staff and said, " What about your costs of material ? " They replied, " We have never had any system to show that. Our rule has always been to undersell the other firm." You can easily understand how the business could go to the wall under those conditions in these times. At the end of last century it was possible because there was no competition, but now the business had to go under because a very elemental condition of safety had not been considered. Of course that could not have any application to rubber costs, because we would not go very far on such a basis. We must know what we are doing, and we are going to hear something on the subject now from Mr. Baxendale. I will call upon him to read his paper.

Mr. Baxendale then read his paper as follows :—

In every class of trade the question of the cost of production is of importance to the manufacturer. But where the market is an open one, if there are numerous producers, then in these days of keen competition it becomes vital, as it is only by closely watching his costs and reducing them to a minimum that the producer can hope to hold his own.

So far, the comparatively new industry of plantation rubber has been remarkably fortunate with regard to the gross profits earned, and probably in no other industry of this magnitude and with so many and varied interests involved, are the gross profits so great as in rubber. We cannot expect this to continue indefinitely. Although the drop from " Boom " prices has been very great, a number of producers are still able to show gross profits of upwards of 100 per cent, which, although it should be highly satisfactory to shareholders who acquired their interest at anti-Boom or post-Boom prices, it behoves all of us who are responsible for management to reduce the cost, so far as may be compatible with efficiency. The first step in this direction, I think, may be made by standardising the form of accounts presented to shareholders.

A few years ago the public took very little interest in the question ; but now that the profits are generally on the downward grade, we must all endure criticism directed on production cost. It sometimes requires the patience of a Job to read with equanimity that a certain estate produces at an " all in " cost below another, that we are particularly interested in, when we know that the actual result is the reverse, the reason being that the items composing the " all in " frequently vary very considerably, and some items which one company thinks proper to include are omitted by another. It, therefore, seems to me that it would be to the advantage of all concerned if some common basis could be adopted as to the form of accounts to be submitted to the shareholders, and for ascertaining what is to be included in arriving at f.o.b. and " all in " respectively. I have no doubt that a resolution adopted by this meeting would carry considerable weight in achieving that object.

I suggest that all accounts should show the following three items

1. Expenditure on Revenue a/c. on the estate.
2. Expenditure on Revenue a/c in London, including management to London officials.
3. Selling charges, freight, warehousing charges, brokerage etc.

Against each of these items, which can be elaborated according to taste, might, I think, with advantage be shown the cost per lb. If this course be adopted then the accounts will show at a glance the cost of production and London expenditure—which together will give the " all in " cost, while the Revenue side of the account will show the net price received per lb. The difference between the " all in " cost and net revenue will then show the actual net profit per lb. of rubber sold. No doubt questions will arise as to detail, but if the above or similar suggestion is adopted it will put an end to invidious comparison as to the cost of production by the various companies.

It has been suggested that debenture interest should be shown in cost, but personally I am not in favour of its inclusion, and think it should be shown separately. There is a strong argument against including depreciation, as the latter has often been used to constitute a secret reserve rather than an actual provision to provide against loss through exhaustion of the asset by legitimate working.

I am not a chartered accountant, and my only reason for dealing with this matter is as a planter and director of planting companies. I do not think that most of us are wedded to any definite scheme, but there are various items that might be dealt with. In discussing the question just before the meeting, our Chairman expressed the opinion that it would rather complicate the matter when rubber is sold at Singapore or Colombo, for instance. I think that could be dealt with by the gentlemen in this room. Where there is a Singapore charge it might be dealt with as if it were a London charge.

Mr. F. A. BAGNALL : On this question I think that first of all there will be a difficulty if we are going to give all this information. There is a diversity of opinion as to how much information should be published in estate accounts. Among shareholders, the smaller the man the more noise he makes, and he asks for no end of information. If we are going to standardise the accounts, first of all we should give the f.o.b. costs, which would include all the extra expenditure on the estate, and then in the case where rubber is delivered in London and not sold at the nearest part, say Singapore or Ceylon, we should give a c.i.f. quotation. The question is as to what are to be regarded as "all in" costs. In all-in costs perhaps the secretary's salary is not included, or the directors' fees, or debenture interest, and so on. I think, if you are going to give an all-in cost, you should include everything that is chargeable against revenue. It is not all-in unless you include all expenses.

Mr. J. C. GARDNER: With regard to all-in costs, it should be possible to arrive at a standard for directors and others responsible for the accounts. It does not matter what that standard is, provided that everyone who compares one company with another can say that the all-in costs are a certain figure ascertained on a definite basis. I quite appreciate Mr. Baxendale's difficulty about the inclusion of debenture interest, because he naturally feels that in issuing debentures instead of more share capital the costs would be reduced by that amount. But there is always the difficulty that a company raises money in other ways, borrowing from the bank or the Government, and if you exclude one form of interest it is very difficult to know where to draw the line. I agree with Mr. Baxendale on the question of including depreciation. We have seen, especially in more prosperous times, that when directors wanted to show a big reserve they wrote off more for depreciation than was absolutely necessary. As to the difficulty which has been foreshadowed about the cost if sold f.o.b. Singapore or Colombo, or wherever it may be, I imagine that if you take these costs in, the capital charge, the brokerage, and the freight, in a case where it would sell in London you could bring the figure back to the Singapore or Ceylon cost, and then the one company could compare with the other company its net amount received for the produce. Therefore, if you have the net amount received from the produce on the one hand, and on the other hand you have the all-in costs, you can compare one company with the other as to the net amount of profit per lb. that is made. It seems to me that if in comparing accounts, possible investors contemplating investments in companies could see what profit per lb. a company was making, it would be a great advantage.

Mr. McEWAN: Of course this is an all-important subject to all of us, but I cannot admit the necessity of uniformity either in accounts or system. In some of our Colonies, particularly in Canada and Ceylon, the law lays down the form of accounts and we have to comply. Most of the directors in this country would object very strongly to having any such form laid down for them. I would personally be strongly opposed to any Government or body saying that I had to do my accounts in any particular way. Since the rubber boom we have had attempted management of the companies by the Press. The Press has asked us to do certain things. I think very highly of the Press in its proper function, but I do not think that is its proper function. We have been asked to give a good deal of publicity in connection with the affairs of our companies, but we would have been wiser if we had not done so. The chairman of a well-managed company does not answer questions every time they are asked. The annual meeting is the place to give the information, and it is given fairly freely then. As to the question of all-in costs, we are dealing with a new phase of the subject. We are invited now to give for the satisfaction of the curiosity of those who very often are outsiders, a great deal of information that might be withheld. In the old tea days the companies were never asked for this information. I hold in my hand now an account of a company which was recently published. Possibly it showed the lowest all-in cost up to date. The company had no debentures, and that item is not in it. I object to including debentures in the all-in cost of any company. The company that has not got an adequate capital for its business is not a normal company, and why you should put in an abnormal charge I fail to see. In connection with depreciation, we may have a phase of depreciation before us which may prove to be unnecessary. In a well-managed company, that has already been provided for by paying out of revenue as you go along. I quite agree with Mr. Baxendale's general division of all items of expenditure. There are many others that are quite material, but they vary from place to place. We are not all in Ceylon, and there is, for instance, a very large item which has to be paid for export duty to the Government of the Federated Malay States. Then again, there are companies which have to pay a rent charge on their estates, while those who hold freehold lands in Ceylon, for instance, are entirely free from charges of that kind. We are living amid diversity the whole time. The individuality of the secretary or the directors is bound to come through. Until you get a legal enactment, which I hope you will never get, you will not get uniformity. I think the error of rubber so far has been too much publicity in connection with all these things. I do not believe in having too much of this tabloid food handed to me.

A DELEGATE : I take it that your point is that it is not advisable in your opinion to give information, and I rather agree in that, but it seems to me that where directors decide to give information it is as well that it should be set up in such a form that the actual result of the working can be seen. In a great many cases one does see accounts of rubber companies, trade accounts, in which certain items are hidden up, with the result that the general costs of production of those companies look more favourable in one case than in another. It appears advisable, as far as possible, if you are going to give information, to give the accurate information, and to enable the Press, when they report in detail on these companies, to get correct information for the public. I agree that in certain companies they have export duties and so on, but that is for the investor to take into account. It reduces the value of the company by a certain amount, I should imagine.

Mr. McEWAN : I quite agree with the last speaker that there should be the greatest amount of accuracy in what is given, but to give information for the professional forecasts of prophets who wish to deal with four or five years hence is, I think, quite wrong. The individual characteristics of rubber companies are so various that no outsider can analyse them sufficiently well.

Mr. BAXENDALE : You rather emphasised the point that nobody should be compelled to produce his accounts in a certain way. I never intended to suggest anything of the kind. I proposed that some scheme should be formulated to meet the purposes of those who wish to produce their accounts alike. There should be no difficulty in formulating some scheme that would meet the views of directors and accountants in general.

Mr. McEWAN : That would be perfectly possible and desirable in a good many cases.

Mr. BAXENDALE: I cannot see where the harm that is done by newspaper criticism is an obstacle to my scheme. The criticism will go on anyway.

Mr. McEWAN: I think the professional writers for some of the papers are rather tired of it. As for the public, they are very tired.

Mr. BAXENDALE: I was not suggesting this for the benefit of the newspapers. It is complicated and difficult for investors when they have a different form of accounts for every company. Then again, the auditor who has to go through these accounts is over and over again changing his system to meet the peculiarities of the different boards.

Mr. BAGNALL: I think Mr. Baxendale need not worry himself about the troubles of the accountant. He knows his own business quite enough not to be worried with these things.

Mr. BAXENDALE: Does he like to have a different system for each company?

Mr. BAGNALL: As long as the accounts are correct he does not care. They are not his accounts. They are the directors' accounts.

Mr. BAXENDALE: Then I put it that the secretary has a certain amount of trouble if he is the secretary of half a dozen different companies.

Mr. McEWAN: I think in all probability in one office the utmost uniformity will prevail, having regard to the fact that the different estates may be in different countries and under different systems otherwise.

Mr. BAXENDALE: It can be uniform as far as the particular points I have raised are concerned. I merely suggest uniformity on those points, as I think from what I have read and heard discussed, the matter is one of moment.

Mr. McEWAN: There may be accounts that are not perfect. We have had a great many amateurs coming into the company world in recent years. It may be that what you speak of is a cause of complaint, but it has not reached me.

Mr. E. D. WATSON: You have mentioned a matter which appears to me, and perhaps to nobody else in this room, to be of some importance, and that is the question of accounts having regard to the shareholders. You are considering them from the directors' point of view, but surely the matter as it appeals to shareholders should be taken into account. The shareholders coming into your companies come at your invitation, The shareholders are given very glowing accounts and anticipations of what is going to happen, and the public have supplied to your business some £60,000,000 to £100,000,000. You should consider the position of the private investor as well as the position of the management of the company. I have no desire for full accounts personally, but there are many companies in which the accounts should be more candid. You give away the secrets of your full production, where the manufacturers take care that they do not make their output known. You would do much better to withhold that kind of information than the particulars some of you desire to withhold.

Mr. McEWAN: I might say a word in reply to the gentleman who has just sat down. I had a report in my hand concerning the prospectus of a company, and that prospectus spoke of rubber selling at 2s. a lb. in London. It has not yet come down to that. Reports made by directors to their shareholders are entirely a matter between the directors and the shareholders. The remarks which have been made just now might well be addressed to the directors of the companies in which the gentleman is interested instead of a conference of this kind. The Press has been very good in urging economy and reduction of costs in connection with rubber companies. I do not know a single company that has done anything deliberately to reduce its working expenses. It would be suicidal to do so. A rubber estate should be well kept up, and the whole of the work well done. If you begin to economise in these things in all probability you will be doing harm. The rubber estates in the East have not made economies, but their working costs have reduced normally, because as each year goes on the collection of latex can be carried on without any additional expense. When I was speaking of people being sorry they spoke, I was not alluding to directors or shareholders. I spoke of professional forecasters who issue books to show what is going to happen four of five years hence. These outsiders build up expectations that the public fail to realise. For those representations the directors are not responsible.

Increasing the Yield of Funtumia Elastica or "Lagos Silk" Rubber.

By

PROF. EDM. LEPLAE.

(Director-General of Agriculture of the Belgian Congo).

Extensive plantation of *Funtumia* (*Kicxia*) *elastica* or " Lagos Silk " rubber, have been made in nearly all the tropical colonies of Africa. This rubber tree grows easily, and its reproduction by seed offers no difficulty at all. The rubber is of very good quality.

Objections to this tree are (1) its branching habits and (2) its inferior yield, compared with *Hevea*.

The *Funtumia* tree, when planted more than a few feet apart, puts forth numerous lateral branches, and this excessive branching extends even to the lower part of the stem. A *Funtumia* left to grow at will in the open is a dense and bushy mass of healthy-looking leaves, from the ground to the top.

This lateral branching altogether prevents proper tapping. Pruning has been tried, but the results are unsatisfactory, the bark never getting rid of the scars.

A much better plan has been advocated by Dr. Christy, who advises that *Funtumia* be planted very closely at first, and thinned afterwards. Closely planted the trees grow upwards with very few branches, and even shed these after a while, a perfectly even bark being finally obtained.

The gradual thinning out of the plantation should be done with care, and the roots of the trees cut down should be removed to prevent the spreading of disease. By this method, upright, clean and easily-tappable stems are obtained.

The yield problem is not so easy to solve, and till now *Funtumia* plantations are greatly inferior in yield as compared with Para rubber. However, experiments made in the Gold Coast and quite recently in the extensive *Funtumia* plantations of the Belgian Congo, have shown that the yield can be greatly improved by suitable tapping methods.

The tapping of *Funtumia* is not done daily or every two days, as with Para rubber, but only twice or three times a year. This makes a great difference in the cost of tapping labour.

The *Funtumia* is tapped from the ground up to the first branches, that is along a length of stem of about 15 to 18 feet.

The tapping can be done either on the Herring-bone system, or by vertical cuts, running from the branches to the ground and about 4 inches distant from each other (Schultze-im-Hofe system).

The Herring-bone method gives the better yield, but the cuts should be quite shallow, as the bark is very thin. In fact, according to Dr. Christy's method, the lines should be cut carefully with a knife, just deep enough to form a channel for the latex, and the actual flow of latex brought about by means of a pricker. This should be fitted with well-sharpened blades, so as to make clean cuts.

According to the experiments made in the Belgian Congo, Dr. Christy's method of tapping is a great improvement on the Schulze-im-Hofe or vertical system, and gives about twice as much rubber per acre.

A still further improvement has been achieved by one of the officers of the Belgian Agricultural Departments, Mr. Sparano, which has nearly doubled the yield.

In the Sparano method, a full herring-bone is traced on the bark, up to 15–18 feet high, but the pricking or tapping is done gradually starting from the base of the tree, only 4 laterals being pricked every day. It takes several days to reach the top of the herring-bone, 6–8 laterals being pricked on the last day.

The flow of latex obtained by this new method was much better than by any one of the methods used previously, and a comparison between the Schulze-im-Hofe, the Christy and the Sparano method has shown the relation to be about as 1 : 2 : 4.

New and more extensive experiments have been started in the Congo plantations to prove the value of the Sparano method. It would be highly interesting to carry out similar experiments in other *Funtumia* growing colonies.

A Practical and Cheap Method for Determining the Fertility of Rubber Soils.

By

E. LEPLAE,

Professor at the Louvain University, Director General of Agriculture of the Belgian Congo.

Since the war against the Arabs has suppressed the slave trade both in the Tanganyka and Welle districts of the Belgian Congo, numerous experimental farms have been established by Government and devoted to various tropical growths, amongst which the cultivation of rubber is paramount.

The Agricultural Department of the Belgian Colony endeavoured to determine the fertility of the experimental plots and the nature and amount of chemical manure that should be applied to each of them.

These researches were all the more interesting, from a practical point of view, inasmuch as most tropical soils very rapidly lose their original fertility. After being under cultivation for a few years, very often after four or five years, these soils have to be left bare, as it no longer pays to produce crops on them.

This is a serious drawback, as the farms have to be shifted, or, if the raising of vegetables is intended, new lands have to be cleared at great expense at a greater distance from the towns or villages. Where rubber cultivation is the principal object, the soils rapidly deteriorate on account of the clean weeding, and some method, therefore, has to be devised to maintain their fertility. Moreover, principally in the case of young rubber trees, the use of a moderate amount of suitable manure always proves of great benefit to the young growth. This in its turn secures more rapidly a good canopy of foliage, which impedes the growth of weeds and cuts down the expense of clean weeding.

In order to investigate the fertility and manurial requirements of the soils, the Agricultural Department of the Belgian Congo first made use of chemical analysis.

A laboratory was erected some years ago at the Botanical Gardens of Eala on the Equator, and some soil investigations were made. However, the equipment of a chemical laboratory in Central Africa proved very costly and difficult, and two years ago this laboratory was transferred to the Zambi experimental station, a few miles from Boma, near the mouth of the Congo river.

Another fully equipped laboratory for analysis of soils was started in 1912 at Elizabethville, Katango. In these two laboratories a good number of Congo soils were investigated, the analytical method being identical with the process used by Prof. Wohltmann in his researches on Brazilian and German Colonial soils.

The results of these analyses are quite interesting, but a difficult point lies in their interpretation.

As a matter of fact, chemical analysis shows the quantities of possible plant foodstuffs contained in the soils, but gives very little, if any, information regarding the amount of these manurial constituents which are immediately available, *i.e.*, that can be immediately utilised by the crops grown on the land from which samples have been taken.

For instance, if analysis shows that 5,000 pounds of potash are present per acre, the planter wants to know how much of this potash can be absorbed by his plants or trees. The growth of a plant or of an animal does not depend on the quantity of food that is put before them, but on the amount of food which they actually eat and digest. Now a large proportion of the useful components of soils are in such a form that their absorption by the plants or trees is very slow indeed.

Chemical analysis gives but very few indications in this direction, so that the conclusions to be drawn are to a large extent guess work.

Although it is quite feasible to make a good guess on these matters, it would be much more useful from a practical point of view if the fertility of a given soil could be ascertained in a more precise way.

Moreover, a chemical laboratory is a very expensive item, as the running of this entails a costly equipment and high fees for the chemist.

* * *

A cheaper and better method of ascertaining the fertility and the manurial requirements of soils is to be found in the use of *pot-cultures*, which have been largely used in Europe.

In this method about 8 or 10 good samples of soil are taken from several parts of the field (about 600—700 pounds weight) and carefully mixed. Zinc or earthenware flowerpots, each holding about 10 pounds of soil, are filled with the same, and each pot is charged with a differently composed manure. The pots are put in a sheltered place on benches, in the open, with a movable roof so that they may be protected against too heavy rains and hurricanes. If necessary, they are watered every day, care being taken that the moisture should be kept equal in all the pots of each series.

A suitable crop is sown in these pots; oats are a favourite seed for such experiments; corn or mealies do equally well, but should be sown thickly, so that each pot holds several plants. The result can, as a rule, be seen quite distinctly in a few weeks, the growth in the individual pots being very different. Those which have not received the right manure produce only dwarfed and unhealthy-looking plants, whereas the pots which have received a manure well adapted to the requirements of the soils produce large and healthy plants.

The indications given by these pot-cultures are so striking that anyone can read them at sight.

However, good results are to be expected only when the nature and the amount of manure used in each pot are properly adjusted.

As a demonstration of the usefulness of this easy and practical way of studying the manurial requirements of given soils, I can quote the following instance.

Two soils in the Lower Congo district were compared: the first was sandy and seemed very poor; the other one was a rather heavy loam, and was thought to be much more fertile than the former.

Chemical analysis gave the same results in both cases, but the pot-culture experiments gave quite different results. The latter proved that the sandy soil was lacking in no element except nitrogen, whereas the loam was lacking both in nitrogen and phosphoric acid, and was also the poorest in available lime.

The sandy soil, as shown by these experiments, gives good crops with nitrate of soda alone, while the loam has to be manured with nitrate of soda, phosphates and lime.

This easy and very cheap manner of obtaining precise information on the manurial requirements of soils can be safely recommended to rubber planters in the East. All details on the manuring of the different pots can be had through the Agricultural Departments.

NOTE.—[The original papers read at the Congress were taken to Belgium by Mr. Ed. Leplae to revise; war was declared and he despatched them by messenger coming to London, but they never reached the Editorial Office. Mr. Leplae having returned from the fighting line has re-written the papers briefly from memory. EDITORS.]

The CHAIRMAN: None of us can help regretting that we have not heard the full papers, if we can judge as to their quality from the abstracts. I am sure M. Leplae will be very glad to answer any questions that members of the Congress may wish to ask.

Mr. BAXENDALE: I should like to know whether the plants you grow in the pots experimentally are the products you propose to grow.

M. LEPLAE: They are not the plants we are about to grow, and there is a great difference between the manurial requirements of plants, but it is not so great as to make any difference as to special fertilisers of this nature. If one plant shows you that nitrogen is absolutely deficient in the soil, it will be deficient in that soil for all plants except leguminous ones. With small *Hevea* trees you can put about ten or fifteen in one of these pots and let them grow for some months. We believe that when we are applying these experiments to such trees as the *Hevea*, or coffee, or tea, or coconuts, it is better to grow that special plant which is subsequently to be grown, but the growing of coconuts, for instance, is very difficult in pots. It might do when they are small, but then they are deriving their food from the nut itself. What is applicable to another plant would certainly be generally applicable to coconuts, I should imagine.

Mr. **Baxendale**: On the question of rubber needing manures, you would apply that to Africa, would you not ? You would not apply it to the world at large. Fertilisers on plantation soil in Malaya have not had the slightest effect. I have, however, seen them in Ceylon. Personally I have made experiments with fertilisers in Malaya, but I have not obtained any difference through them. We find that we are very rich in all properties except lime ; there is a deficiency as far as lime is concerned. I have already put in a report on that matter, in connection with the paper by Mr. Hamel Smith. Some time ago I saw a report by the Federated Malay States Government which told us that rubber requires to collect about one-tenth of the manurial properties that are taken out of soil by the average crop of wheat. It was suggested that the falling leaf would by itself supply all that was taken out of the soil by the tree.

M. **Leplae**: Of course the whole of the trees, rubber trees as well as others, never require the same amount of manure as you would have to give to cereal or even leguminous plants. The tree replenishes itself from the air. But often there are young trees that need some manuring, and when you apply the manure to them you observe that the difference in vegetation is very great indeed. I have seen this in one of the islands of the Dutch East Indies, opposite Singapore, where there is a heavy clay soil, and the trees, as a rule, were growing rather slowly. Guano was employed. The difference between the trees that received a small application of guano and those that did not was enormous. I have seen manuring by more natural means round the compounds where the natives live. In this case, of course, nitrogen is principally given. These trees grew three or four times as big.

Mr. **Baxendale**: You are speaking of exhausted soil ?

M. **Leplae**: No, no ! These were virgin soils. In virgin soils you find an enormous quantity of nitrogen that is not available for the plant ; that is to say, the plant cannot use it because it is in certain forms allied with iron and so on. If you apply nitrogenous manure in such cases you will have very good results. We believe in the Congo that it is always very good to push the trees on a bit when they are young. Later on, however, you would have to stop the manuring, as it would be too expensive.

Mr. **Baxendale**: I notice that a number of growers manure their trees now, but we have not adopted this system in the Malay States. We get better results there than in Ceylon.

M. **Leplae**: I believe experiments have been made by the Agricultural Department.

Mr. **Baxendale**: I am speaking as a planter. Manuring is not generally adopted on the estates I have to do with.

Invention and Its Relation to the Rubber and Textile Industry.

By

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AND

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It is not our intention to describe the development of invention in the Rubber and Textile Industries, since such a description would be co-extensive with a history of these industries themselves.

Our object is rather to state the nature of an invention, to illustrate it by examples, to explain the manner in which our Patent Laws deal with invention, and to discuss the bearing of these matters upon individual inventors and the industries as a whole.

In the first place, then, we will not concern ourselves with any metaphysical inquiries into the meaning of the term "invention," but we will simply state that an invention is an improvement in manufacture which can form the subject-matter of a valid patent. Any improvement which fulfils this one condition is entitled to the name of invention, from an epoch-making discovery, such as the first process of vulcanisation or the first Jacquard Loom, down to the smallest detailed improvement arising subsequently to these discoveries.

(1) The first point to be noted is that an invention must be a manufacture; it must be connected with a commercial apparatus or process or product, and not be merely an idea or a principle. But in this connection, the word "principle" is very misleading; it is best, therefore, to avoid the use of this word and to consider in each case whether some new manufacture is involved.

As an illustration we may mention the case of Hictons *v.* Patents Improvements. That invention related to lace-making machines. When making patterns, naturally some of the bobbins were exhausted more rapidly than others, and consequently it required constant and precise attention on the part of the operative so that the bobbins were each changed as they became empty.

It was well-known in other types of lace-making machines that the comb-bar could be traversed end-wise for the purpose of making the pattern.

The inventor had the idea of using this end-wise traverse in a levers machine, and by shogging the comb-bar in this manner he was enabled to equalise automatically the amount of thread consumed by the bobbins.

In this case the only difficulty resided in the first idea; once it was grasped that the shogging movement of the old machines would serve for equalising, there was no difficulty whatsoever in making a levers machine in which this movement would be effected.

Therefore, in this case the whole merit lay in the idea, but at the same time it was essential for the patentee to describe a machine in which that idea was embodied.

We may cite another example : A Paper appeared some time ago in which causes were assigned for the black streaks and bluish spots on certain samples of plantation rubber. Could these discoveries have formed the basis for patents ?

(a) The reason attributed to the black streaks was that lubricant from the washing machines had become mixed with the rubber. This is an important observation, but is not patentable because such a monopoly would prevent a planter from washing rubber with a clean machine. In a similar case (Partington *v.* Hartlepool's Paper Co.), it was HELD that a patent was not valid for placing creosote with a certain object in a paper-making machine. Previous workers had used creosote in paper-making machines for other objects when these machines had become dirty with accumulated resin. The inventor found that when the machine was clean, a valuable result was produced, but this was not patentable because it would have prevented anyone from cleaning their old machines and then proceeding to do what they had done before. It might, however, be patentable to provide a new attachment to the washing machine, in order to prevent the lubricant from touching the rubber.

(b) On the other hand, the blue spots in rubber were thought to be due to bacterial action. In this case a patent could have been obtained for preventing such spots by adding antiseptics to the latex if this had not been done before. Here the inventor would not only have made a discovery, but would have supplemented it by the suggestion of a new step in the process of preparing rubber, and therefore he would have introduced a new manufacture and not merely suggested a new idea or made a new discovery.

We conclude, therefore, that if an inventor is to obtain a patent, he must have an idea which leads to some difference in manufacture.

(2) We may now go a step further. It will be at once obvious that a patent cannot be granted unless the manufacture is new. If the inventor does not bring forward something new, he has nothing to offer the public in exchange for the monopoly which he obtains. The British Statute demands that the invention must not have been described, or published, or publicly used in England.

In the Haskell Golf Ball Case, the patent was for the combination of a core of rubber thread wound by hand under tension, with a gutta-percha cover. This patent was HELD invalid, for one reason because this very combination had been actually used in public by Fernie and by Capt. Stewart ; therefore, although the Haskell ball was an enormous success, and revolutionised the game of golf, it was not considered new in the sense of the Patent Law. Again, it is not sufficient to find out the theory of what has previously been done empirically, unless this leads to the process or operation being carried out to yield different results in practice. For example, it is known that plantation rubber frequently contains traces of acid, resulting from the acetic acid used in coagulating the latex. Would it have been possible to patent the first suggestion to wash plantation rubber at the works, in order to free it from this acetic acid ?

In spite of the fact that wild rubber is always washed in the works, it might not have been obvious then to wash plantation rubber which arrives apparently dried ; if advantages were obtained by performing the washing process, it might have been patentable at that time except for the fact that, in the early days of plantation rubber, it was sometimes shipped in wooden cases so that it arrived containing splinters of wood. Such rubber was, therefore, washed in order to remove the splinters ; it follows, therefore, that without knowing it, persons who washed the rubber for this purpose would also remove the acetic acid and probably unsuspectingly anticipate a patent for the removal of acetic acid from plantation rubber.

We conclude, therefore, that a patent will not be valid if the invention has previously been described or used. The simplest test is this : Would a patent for the invention interfere with the right of any person to repeat or perform actions he had previously done or suggested ? If the patent would interefere with such rights, it is invalid. If, however, the patent only prevents people from doing something which they never had or might have actually done, then it may be perfectly valid.

(3) We now come to a third question. It is quite possible that an invention may be for a manufacture and that it may be new in the sense that the precise thing has never been known before. Beyond all this, however, it is essential that an invention shall involve a degree of ingenuity. It must involve the exercise of the creative rather than the imitative faculties ; it must not merely be an improvement such as any skilled operator would naturally make. The reason for this is that patents are designed to reward the inventor and at the same time to benefit the public. The inventor secures the rights to fourteen years' monopoly of the exercise of his invention ; on the other hand the public obtain the right to use that invention at the lapse of the patent's life, and, therefore, the stock of general knowledge is enriched. But it is essential for this contract that the inventor must bring forward something distinctly new. It would not be fair to grant a monopoly for every improvement of trivial importance, such as would naturally be made by any person skilled in the particular industry. If this were so, progress would be choked instead of encouraged, and, therefore, the rule is that a patent is only upheld, provided that it represents more than the mere intelligence and application of a skilled person in any industry. To determine whether this is the case, the usual test is to see whether some new and unexpected result is produced ; if so, it is generally HELD that the improvement is more than mere skilled workmanship and rises to the dignity of invention.

The point will be clearer by considering various examples.

Suppose, for instance, that it is already known that india-rubber balloon fabrics deteriorate because of the chemical action due to the rays of short wave length, which are especially strong in the upper regions of the atmosphere. Suppose it is also known in photographic work that the actinic rays of light can be filtered off by using a yellow screen. It is probable that the *mere* suggestion to protect balloon fabrics by a yellow film would not involve ingenuity, given the above two assumptions. The disease is known, namely, the rays of short wave length ; the remedy is known for purposes of photography. These fit like lock and key, and it is obvious to put two and two together and to arrive at the suggestion to use the same remedy in the analogous case of balloon fabrics.

Therefore, although this proposal might be new, it would not be ingenious, and would not, therefore, represent an invention under the imaginary conditions we have mentioned.

If, however, the inventor had described special means of attaching the yellow films or special pigments suitable for use with rubber, then a new problem would have been solved and the result would probably be patentable.

Similar conditions arise in patent cases every day. For instance, in the Haskell case cited above, it was stated in the House of Lords:

" Gutta-percha was, I think, proved by the evidence to be the only known substance suitable for the outside of a golf ball, and there is, therefore, no element of invention, no ingenuity or originality in putting a cover of this substance on a ball of well-known materials, form, and construction, and using the composite ball so formed for golf. In substance and effect, this is all the patentee has done."

It will be clear that considerations of this kind frequently become very subtle, but, broadly speaking, it may be said that even a mere scintilla of invention is sufficient to support a patent.

We conclude, therefore, that beyond being a new manufacture, an invention must involve some creative element. We might say that the recipe for making an invention is this:—

> Take what is known; add to it the knowledge of the craftsman; then do something ingenious and thus breathe life into the dry bones, and you will create an invention.

(4) Having made an invention, an inventor cannot obtain a patent until a suitable specification has been filed. This document must comply with two conditions. First, it must explain fully the nature of the invention and the way in which it is to be carried out in practice. This is the information which is to serve the purpose of enabling the public to exercise the invention after the lapse of the term of protection.

It is the disclosure of the inventor's secret—the payment which he makes for the monopoly which he receives.

The second condition is that the inventor shall claim what is new. This is to enable the public to determine exactly what it is which they are prevented from doing until the patent has expired. The claim, therefore, must be confined strictly to the novel invention which has been made.

These two requirements are sometimes contradictory, and we will discuss them separately.

(a) First, then, the specification must be a full and fair disclosure of the invention. In the case of Gandy *v.* Reddaway, the invention consisted in making the driving belts of hard woven canvas steeped in linseed oil. This was a most useful improvement, but it was proved at the trial that while there were ten brands of hard woven fabric on the market, only two of these were suitable for making belts. One kind was too weak for large belting, whereas another kind was not sufficiently flexible for small belting. Consequently, the patentee had not told the public the full secret to obtain success. It would have been necessary to make experiments to find out which of the ten known brands would yield the desired result. Therefore, the patent was HELD to be invalid.

In deciding as to whether a specification is sufficient and clear, the standard is not a scientific but a technical one. If language is used which would mislead persons skilled in that industry, as in the Gandy case, the specification is bad. If, however, the language is quite clear to the manufacturer, the specification will be good, even though slight scientific inaccuracies are present. For instance, in the case of Dick *v.* Tullis, the patentee explained that he made driving belts by impregnating fabric with gutta-percha. As a matter of fact, microscopic examination showed that the separate textile fibres were not actually impregnated by the gutta-percha, which merely filled the interstices between the individual fibres. This was HELD to be unimportant, however, since the word "impregnate" was quite clear to the practical man.

At the same time the utmost accuracy of language is desirable in specifications, because it is difficult to foresee whether inaccuracies will be considered to be merely of academic interest, or to be misleading in practice, in which case they would be fatal. Further, a patent may be bad, even though it contains no inaccuracies, if it is insufficient to explain the invention to skilled persons. The public must be clearly given all necessary information, and not simply left to make experiments until they reach the same result as the patentee.

(b) The second requirement was that the specification must definitely claim what is new. This is, perhaps, the greatest difficulty in drafting specifications. If the claim is confined to a description of the invention in its best form, it will be open to infringers to make variations and thus escape from the consequences.

Therefore, a claim is usually drafted so as to generalise the invention. The apparatus or process is mentally dissected and the main claim is drawn to the essence of the invention, expressed in the widest terms. It is the duty of a Patent Agent to foresee the variations which would be made by an infringer and to make the language of the claim sufficiently wide to cover these variations. The great danger is, however, that if this is carried too far, the claim will embrace something old, in which case the patent will be invalid.

For instance, in the case of Palmer *v.* Pneumatic Tyre, the claim was for a fabric having one set of separate parallel threads embedded in rubber crossed at an angle by another set of separate parallel threads embedded in rubber, so as to secure strength in two directions without any sawing action.

The claim was for the fabric itself, and not for a pneumatic tyre made therefrom. Consequently the language of the claim was so wide that it was anticipated by a case of public use in another works. In this case, a fabric had been made which answered the above description, although it was not for pneumatic tyres, but represented merely a stage in the process of manufacturing solid rubber tyres.

This shows the immense importance of making the claim cover the real essence of the invention and not being worded too broadly.

On the other hand, a correctly drawn claim should be narrow enough to escape anticipation by everything already known, but wide enough to include any variations likely to be made by infringers.

The Dunlop cases furnish an instructive example in this connection, but the subject is too complicated to be discussed here.

Summing up, therefore, the ideal specification first explains fully, clearly, and accurately the nature of the invention, and then claims the essence of the invention in careful and precise language.

(5) When a patent is infringed, the question mainly depends upon the interpretation of the claim in the specification. Many difficult questions arise in this connection. For instance, in Roger *v.* Cochrane the claim was for a golf ball having a core of incompressible fluid. The liquid usually employed was water, but it was stated in the specification that other liquids or semi-liquids could be employed.

The defendants used a ball having a core consisting of a jelly containing 15% of gelatine and 85% of water. It was HELD that from a practical point of view, this jelly was an incompressible fluid, and therefore such balls infringed, but, even if not, it was shown that bacterial action was very likely to occur, so that in a large proportion of the balls the cores of jelly decomposed to yield an evil-smelling liquid. In this case, therefore, even if the ball were not an infringement at the time when it was made, it would be an infringement when used with the core in the decomposed state.

Examples might be multiplied, but it is enough to say that the courts always decide infringement cases by considering whether the defendant has appropriated the substance of the invention, though the main point to consider is invariably the inventor's claim.

(6) Probably sufficient will have been said to show that it is frequently excessively difficult to decide whether a given improvement is an invention or merely the result of skilled workmanship. In granting patents, different countries have approached this question in different ways.

In Germany, before a patent can be obtained, it is necessary to demonstrate to the Examiners that the improvement is actually an invention. A rigorous search is made through German and foreign literature, and the inventor's statements are submitted to the strictest scrutiny. It follows that a German patent is often difficult to obtain, and injustice is sometimes done because the inventor is unable to demonstrate theoretically that his invention is really valuable and novel, whereas if he had been given a patent, he might have achieved great commercial success, and it might have been found that an entirely new effect was produced.

The French system is diametrically opposite. The inventor submits a specification, and the patent is granted without question, provided that formal requirements are met. This means, of course, that there is absolutely no guarantee of validity, and, therefore, it is difficult to sell a French patent unless most exhaustive investigations have been made to determine whether it would be likely to prove valid in a French Court of Law.

The present English system is in some ways a happy compromise. The Examiners make a search through English patents of the last 50 years, but not through foreign literature. They will allow the patent provided that the claims represent something different from the results of the search. In other words, they consider partly the question of novelty, but not at all the question of ingenuity; this is left for the subsequent determination of a Court of Law. Hence the inventor has the great advantage of knowing that if he can show something different from what is old, he will be able to obtain a patent for it, whether the difference appears important or not. Then he will be able to ascertain by practical experience in manufacture whether the improvement is really sufficient to make his patent a valid one.

Those who have had Works' experience will recognise at once that there are many apparently unimportant details which are absolutely vital in manufacturing on the large scale. At first sight many variations might appear to be absolutely trivial and yet in practice they might make all the difference between success and failure.

Therefore in England it is frequently advisable to patent an improvement, no matter how slight it may seem. If it really represents a difference from old practice, it will be possible to obtain an English Patent, and it may well happen that practical experience on a large scale will show that the change was so important as to make the patent valid.

Within the limits mentioned above, most discoveries are capable of forming the subject matter of a patent. The improvement may consist in combining two old steps so as to produce a new result. It may consist of omitting one step from a known series of processes. It may consist in excluding an undesirable ingredient. For instance, the first person who discovered that porosity of rubber goods might be caused by moisture, could have obtained a patent for excluding moisture by very careful drying of all the materials employed, if it were not for the fact that this is done as a matter of course in every rubber works.

Again, invention may consist in simply selecting times and temperatures which give a new result in a certain process. It will not usually require invention to modify time and temperature of vulcanization, because it is known that the extent of cure depends upon these variables. In special cases, however, exceptions arise. For instance, Marckwald and Frank recently suggested that cable insulation deteriorated because of the wandering of colloidal copper sulphide due to under vulcanization. As a remedy they suggested curing the cable insulation by rapid vulcanization at high temperature so as to cure the rubber fully and yet to avoid heating up the wire inside, thus avoiding formation of copper sulphide, relying on the fact that rubber is a bad conductor of heat, and, therefore, in a rapid cure, the wire will not be heated, at all events at the beginning, when much free sulphur is present.

It is probable that cable insulations have been cured in this way before, but if not it would certainly be an invention to select a time and temperature of cure which would prevent the formation of colloidal copper sulphate and the subsequent tackiness of the rubber.

In conclusion, we may say that it seems probable that more patents will be taken out in the rubber and textile industries than has been the case in the past. In the case of rubber, empirical methods have hitherto been largely employed, but scientific investigation has now made a place for itself, and this will react upon the development of invention in several ways. It will tend to increase the number of inventions which are made. On the other hand it will tend to overcome the objection to patenting which perhaps existed in the past owing to the difficulty of analysing rubber compounds. This meant that secret working was often employed because analysis was not sufficiently advanced to enable a rival to discover a secret by examining and testing the finished article. On the other hand, however, it was more difficult to prove infringement for a similar reason.

Both of these tendencies will now be inhibited, since the analysis of rubber has made great strides. For instance, we may mention the work of Hinrichsen and others on the Polarimetric method of differentiating between the resins of the Hevea and of other botanical species—a problem which was hitherto almost insoluble.

In the textile industry similar conditions prevail; for instance, in the finishing and dyeing of fabrics and fibres to obtain fast colours, and the introduction of pattern into every type of weave. Many recipes have been handed down traditionally from one generation to another, but there are many signs that these conditions are being effected by the recent tendency to employ the resources of scientific research.

The situation, therefore, appears hopeful. Advance is bound to be more rapid if it is assisted by scientific investigation, and if the results are published in the form of patent specifications, so as to enrich the knowledge of the whole community instead of remaining the secret property of individual firms. The old system implies an incalculable amount of overlapping; the same work is done in the experimental departments of many different concerns. It seems much more in accordance with the spirit of the times that the progress of an industry shall depend on the co-operative work of every member, and the patent law provides a means by which this can be done so that the industry as a whole gains fresh knowledge and the inventor as an individual secures the reward of his skill.

Growers' and Manufacturers' Conference.

WEDNESDAY, JULY 1ST, 1914.

THE RUBBER GROWERS' ASSOCIATION

(INCORPORATED).

An important conference was held on Wednesday, 1st July, 1914, between the Council of the Rubber Growers and leading manufacturers, on the subject of the preparation of rubber on estates. Mr. Richard Hoffmann presided.

The CHAIRMAN, in opening the discussion, said: I have the honour to ask you to be good enough to discuss the vital question of the preparation of rubber on Eastern plantations. You will, I think, admit that this extensive and successful Exhibition is an opportunity not to be lost, to go into the question of what style of rubber is likely to suit manufacturers best. It is certainly to be regretted that whereas the rubber from the West arrives in two or three grades, that from the East is almost as varied as the articles into which our raw product is made. Until quite lately we producers hardly knew any of you gentlemen, the users of our product, but latterly we have to our greatest pleasure learned to know a few of you, and I may go further and say, learned to greet you as associates and friends out for a common object, namely, to benefit each other.

Some of you, however, tell us one thing and some another. Only on the opening day of the Exhibition one important manufacturer whom I specially asked to be present here to-day said to me, "What is the good of your Conference. We all want the same thing." I asked him what that was, and he said, "Why, smoked sheet and brown crepe." But, gentlemen, at a luncheon we had the pleasure of attending the other day, our host said he wanted nothing but unsmoked sheet. A third manufacturer has told me at this Exhibition that he still prefers Fine Hard Para.

Now, gentlemen, do you want us to send you smoked or unsmoked sheet, or do you want all our grades, or would you prefer us to send you home Fine Hard Para, or do you rejoice in paying your money and taking your choice? Please bear in mind that if you want unsmoked sheet, you must put up with, here and there, slight signs of mould or spots, as it is very difficult to dry unsmoked rubber. But then if you want this form of rubber surely you cannot expect us to make it unless you pay top price for it. Unfortunately our brokers always value unsmoked sheet at 1½d. to 2d. under first grade. Now, we are not going to strive to make an article which fetches something below top price. What we want to know is, what grade of rubber will you give us top price for?

You continue to pay 9d. or 1s. more for Fine Hard Para. Now, why cannot we ship you an article which will serve your purpose even better than our Fine Smoked Sheet, which is to-day again at the head of the list of plantation grades? Let me first remind you wherein our smoked sheet differs from Fine Hard Para. Fine Hard is, as you know, prepared by coagulation by smoke and evaporation. We prepare our rubber by coagulation, not by smoke, but with an acid, and smoke afterwards. The process is, therefore, reversed. We eliminate our moisture first by coagulating in a trough; when we see the particles of rubber running together like a junket, we then pour off our surplus liquid, and I am doubtful whether in this liquid which we pour off some ingredients are not lost which might be beneficial to the rubber. Now, do you want these ingredients in or out? They are called proteins, and consist of sugars, albumens and other things. Are these better in or out? If we prepare our rubber in the Brazilian fashion they remain in. This I proved only the other day, when our chemists concluded their remarks, on sending me in an analysis, with the following words:—

"We are of opinion that this sample is of good quality, and better than the average plantation smoked sheet."

Now, if we can ship you a better article than the best we are shipping you to-day, will you pay for this better article, and will you inform us what form this better article should take—provided always there is a better article? A manufacturer said to me the other day, "Why on earth should you bother, or why should you be jealous of Fine Hard?" Gentlemen, jealousy in not in question. There is, I hope, room for everyone, but why not help us to ship you an article which will, if possible, give you even better results than you are getting now? Perhaps your answer is, "We want all your grades," but then if there is an article which is better than our best, tell us in what form you want it shipped, and those of us who are enterprising enough to make the tip-top grade are surely entitled to derive a benefit in pounds, shillings and pence.

I may say that I think personally we could ship a grade even better than Fine Hard, and if not better, certainly cleaner, and giving you consequently a greater efficiency by reason of less loss in moisture and dirt. The question of purity also centres in this discussion, for I raise the point that it is perhaps just those impurities which are retained in a smoke coagulated rubber that you would desire to remain in, as they may add vim and verve to your manufactured article.

There is another point, and then I have concluded my opening remarks. It is this, does the smoke impregnated juice in Fine Hard Para tend to mature and keep the rubber in a better condition than that we produce by smoking our already coagulated sheet, because there is a difference. In Fine Hard Para the smoky juice lies between each layer of rubber of the thickness of a piece of paper, whereas our smoke is only applied after the rubber has set and after it has been to some extent rolled or masticated. These and other questions, gentlemen, you will now be pleased to discuss.

Mr. Stanley Morrison: I came to listen, but Mr. McEwan has just asked me to start the ball for the manufacturers. It is a bit awkward, as I did not know exactly on what lines the subject was coming up. Of course what we want is the best we can get, but we are quite used now to the variety of qualities that the plantations turn out. I may say the smoked sheet and the brown crepe are the two qualities we call for, except for special purposes, and then we want fine medium transparent rubber, which we can only get from the plantations. This is only used for certain surgical apparatus, otherwise the smoked sheet and the brown crepe are all we want. We use the brown crepe in preference to first latex because it is 2d. a lb. cheaper. For transparent articles we do not want that fine quality you can see in first latex. Of course you say "Let us improve it, and we will charge you more." I do not quite see the reason for that. You should improve the thing to the best of your ability, and it will of course have to go into ordinary competition. I should think that what you would suggest is more a question as to whether the plantation could not deal direct with the manufacturers. You all know how we manufacturers buy. We do not buy as cheaply as we could do if we went direct to the planters. The reason is that planters do not all of them make sufficient of one grade. We have to go to a broker or dealer and pay him perhaps 1d. a lb. more. We have a standard they must not go below, and by doing our business through the dealers we get that standard, because they take the rubber from perhaps half a dozen different estates, whereas one estate might not have sufficient of that one quality. As to the smoking we really do not mind much.

Mr. MALCOLM CUMMING: I have been asked by one or two gentlemen near me to ask one practical question, and that is, why the manufacturers are prepared to pay 9d. a lb. more for Hard Para than they are for plantation smoked sheet, which they say is equally as good? Can we get any light on that point?

The CHAIRMAN: That is of course the question I am always asking myself. The answer that I usually get from Mincing Lane is that Fine Hard Para is in three, four or five hands, and we are in 500 different hands. Perhaps our chemists can throw more light on this matter than I can. Chemists and manufacturers do not always work together. I have sometimes received raw rubber which analysed better than Fine Hard Para and which sold at 2d. below our first grade. The plantations sometimes send rubber which is in very much the same form as Fine Hard Para. I think this Association would be wise in getting hold of that very fine ball of Fine Hard Para that is in the Ceylon exhibit. I have been putting my nose in it, and it smells even better than Fine Hard Para. For the first time I have seen a ball made of plantation and similar as to its look to the Brazilian, and the Association should find out whether in manufacture it behaves identically with Fine Hard. I want really to raise the question as to whether we are right in masticating our rubber before it has set. That is really the difference between Plantation and Fine Para. Brazilian rubber matures for three or four months, but we masticate our dough before we make the crust. I am sorry, but in my own mind I am a little jealous of the prices of Fine Para, and I would like to see whether we could not remedy the difference and try to produce say four or five thousand tons of similar grade. I do not think the tree or the latex is different, but perhaps our chemists could say a word or two on this matter.

Dr. H. P. STEVENS: Of course, as you say with regard to the question of the difference in price between plantation and Fine Hard Para, it is really for the manufacturer to explain, because he buys the stuff. I take it that there are two reasons, one being that the manufacturer can buy at any time any quantity he may require of Fine Hard Para, whereas he cannot buy plantation in a similar fashion. In the second place there are still a large number of manufacturers who are very conservative. One firm of large manufacturers told me that they are not using any plantation rubber, and many manufacturers still adhere to Fine Hard Para for certain purposes although they also use plantation. With regard to the question of mastication, we have come to the conclusion that it is not a good thing to wash your rubber. We base that opinion on the relative qualities of sheet and crepe rubber. But some of the crepe if not washed too much compares favourably with sheet. I have here a few figures which were recently sent me which had been collected from a number of estates in the Federated Malay States, showing the ordinary routine method of treatment of rubber, whether sheet or crepe, and it is really astonishing to note the variation. Starting off with the quantity of acid added to the latex, the figures varied from one gramme of acid in 500 to one in 2,000. On the question of the number of times the crepe is put through the rollers, the figures are as low as seven in some cases, and in others they run up to twelve and considerably over. All these details vary and, this must have an effect on the quality of the rubber. Concerning the treatment of the mastication of the freshly coagulated rubber there is one other point the Chairman touched upon, and that is the fact that sheet is not worked to any extent ; it is only very gently pressed, and if it is only the machinery that does the damage, that would not apply to sheet rubber.

The CHAIRMAN : It would not entirely, but even sheet must be rolled.

Dr. STEVENS : Putting it to a gentle pressure. Possibly it would have some influence.

Mr. M. M. DESSAU : The remarks of Mr. Morrison with regard to the best qualities of plantation rubber I fully endorse. The smoked sheets and the brown crepe are, as far as my opinion goes, beyond question the only satisfactory grades that can be used to any considerable amount. But you have put the question as to why if these two classes of rubber are found to be so good, the manufacturers do not adopt them at the same relative cost as the Para types. The reason, I think you will find, is that the manufacturers have built up their reputations upon certain good articles They are a conservative class, and are very loth to change their formulas. But as we go on, and as these plantation grades improve, with less free acid—for in the early stages of plantation considerable free acid was left in the crepes—and manufacturers by the assistance of their chemists have devised means to neutralise the defects. I think we need have no concern about the future of the plantation industry. The qualities are equal, and in my opinion much better, providing manufacturers know how to treat them successfully. I think the increase in the use of plantation, as far as this country is concerned, will be of such a character that there will be a considerable displacement of Para, for the prejudices are being gradually broken down. The Continental and American people have gradually led the way, so that as you know we have at this very time manufacturers who proclaim for plantation, who but a very few years ago would have hesitated to make any public statement that they considered the plantation rubber the best.

Dr. P. SCHIDROWITZ : I would rather have heard the opinion of another manufacturer, but will take the liberty of remarking on Mr. Dessau's statement that Para rubber would be displaced in time. I think we were told a year and a half ago that Para was dying, but there is still very much life in it. The imports last year were only some 3,000 tons less than the year before. The question that we have to consider is this, is Para rubber really so fundamentally superior as the ruling prices would seem to show. Mind, I am not speaking of prices for a week or two or even for a few months, but am referring to those of over two years. If there is not that difference in quality, what must you do to get rid of the difference in price, because after all the world is still using some 40,000 tons of Brazilian rubber, not all Fine Hard, but some of it scrap and so on. Even the lower grades such as negroheads are selling above the price obtained for No. 1 grade of plantation. I may say that my own experience, based on experiments and opinions of manufacturers, is that your premier grades as used in the factory are frequently not inferior to Fine Hard, but are superior. There is one point, and it is that the washing of rubber in the factory affects quality very considerably. I recently made some remarks to the effect that manufacturers should avoid washing plantation rubber unless it is absolutely and obviously necessary, but of late we have heard a leading manufacturer saying that no self-respecting manufacturer would refrain from washing crepes. Yet there must be a number of manufacturers about who have no self-respect and yet make very satisfactory articles. There are at least three firms known to me who use crepes for the finest grades of tyres, and do not wash them. I do not think there is any reason why you should not send all your grades home in such a condition that they would not need washing at all. Assuming for the moment that I am right, and that the manufacturers with whom I am acquainted are right, in saying that the best grades of plantation are at least as good as, and in some respects superior to, fine Brazilian grades, why is there this discrepancy? I think it is that the Brazilian grades are less variable than the plantation grades. When you can say to the manufacturer that you can give him a uniform article, or alternately an article the quality of which is specified, he will naturally prefer to pay a little more for your best plantation grades.

Mr. Stanley Morrison: It is quite easy to explain why people have to buy Para. We in our factory have thousands of mixings, and we get orders extending over years for articles which must conform to exactly the same standard. In these cases of repeat orders, if the article was previously made of Para, then we use Para again. As the majority of the articles we supply were in the first place made of Brazilian rubber, and the same thing precisely is called for again, we continue using that rubber. You will see that the manufacturer must have the Brazilian rubber in his factory. As to the differences in the rubbers from Brazil and from plantation sources, the thing amounts to this simply :—We get the Para rubber with all its " guts " complete ; you tear your plantation rubber to pieces before you send it to us. Every manufacturer knows that in going through those machines the rubber loses a lot of its energy and vivacity. There is no doubt that there are one or two ways of treating the rubber on the estate which would be less prejudicial to its chances. You can put it through the ordinary mangle. That will suit the manufacturer a lot better than first latex crepe which has been torn to pieces.

Mr. Richard Magor: How is it that, speaking about two or three months ago, first latex crepe, whether thin fine or blanket, was selling at a higher price than smoked sheet? There are a number of estates which continue to make crepe rubbers only, and their prices in the long run certainly do not fall very far short of smoked sheet. But from what we have heard to-day from the few manufacturers who have spoken, one would suppose we were altogether on the wrong lines in making No. 1 crepe. Perhaps some manufacturers would throw some light on the fact that first latex crepes were selling a short time ago at a higher price than the article the manufacturers say they wish them to produce ?

The CHAIRMAN : Perhaps you are alluding to a little moment a few weeks ago when suddenly crepe went up to 3s. I think that was really a market squeeze. But Para is now always higher than Plantation.

Mr. MAGOR : I was referring to the different grades of plantation rubber. Crepe rubbers were selling above smoked sheet. But if we are going always to be below Fine Hard ought we not to strive to make that article ? Ceylon is showing a quantity of grades. Which are the precise ones that we ought to emulate, not in front of a little urn with a little paddle, but in a large way ?

Mr. A. IRVING : I have just returned from Brazil, where I have had opportunities of seeing the way in which the rubber is worked there. Of course the method, from the point of view of a plantation man, is primitive in the extreme. There is little factory work or general supervision, and it is impossible that there should be supervision. There, it is the work of the individual. The form in which the rubber is cured there, it would be quite out of the question for the plantations to copy, but whether or not it could be copied by mechanical process in the centres is a thing to be seen. Nobody seems to have asked yet what the opinion of the manufacturers actually is regarding the rubber which has been turned out by mechanical process in the Malay States and Ceylon in much the same form as Hard Cured. That point is very interesting. The thing has been done on a very small scale, but it would be interesting to know whether rubber cured in this form would meet the demands of the manufacturer to the degree that he would be prepared to pay the same price as for fine hard cured. I would also like to say a word as to what has said concerning washing and over-washing. It has been cited as a reason why plantation prices are so much below those for hard cure. The plantation sheet rubber is never macerated at all. It is turned out with practically no machinery whatever, and in this case the process practically is only compression, so that if the washing of plantation rubber is quoted as a reason why the price should be so much below Hard Cure, the complaint still cannot be applied to sheet.

Mr. C. E. WELLDON : If I understand aright the manufacturers have told us to-day that they do not like our worked rubber as well as our sheet. Is that so ?

Mr. MORRISON : Yes.

Mr. WELLDON : They consider our smoked rubber which has not been handled, if it were not for the fact that they have to fulfil orders which have all along been produced from Brazilian rubber, would lend itself equally readily and equally well to their purposes. Is that so ?

Mr. MORRISON : Better.

Mr. WELLDON : So that the reason for the present preference is that repeat orders have to be fulfilled for lines that cannot be varied because they have always been made from the Brazilian rubber, but if the manufacturers had their own way they would put our smoked sheet in and turn out a better article. I should like to have that contradicted or corroborated.

Mr. J. M. MACLULICH : I think it resolves itself into a question of prices and supply and demand. The manufacturers a few years ago tried plantations on the old systems, took it into their mills, washed it, mixed it, and broke it down as you do in the wild, and it did not do. I speak as a manufacturer. I was one of those who tried plantation rubber a few years ago and was not satisfied, but I persevered, and adopted the new methods of manufacturing in the mill. I now use no wild rubber at all, and I find smoked sheet equal to any wild rubber, but I have given up the washing. It is a saving really. I find compounds go more readily into the plantation than into the wild rubber, and it does not require that breaking down that the wild rubber needs. In the mill it also appears to be more plastic. In connection with railway buffers I have found that plantation rubber made in the more modern way will give a 6 ton load instead of the 4½ ton load given by fine Hard. It will give a regular strength if properly handled. But as Mr. Morrison has indicated, in most mills in England and abroad there are certain formulas in use. Rubber, as everyone here knows full well, has been an expensive thing to experiment in. The formulas in use for Fine Hard are not the formulas that you need for plantation rubber, and if you alter your processes of manufacture you will get better results. The smoked sheet is undoubtedly the best form of plantation rubber that you can use, and the most uniform. The other grades may be used with equal results in some cases, but generally speaking the results are uncertain. This makes the work of your foreman or man in charge rather difficult, for in most cases these men do not know how to meet the problem of this uncertainty.

Mr. JOHN MCEWAN: We have been a little unfortunate with regard to the response of the manufacturers to our invitation. We asked eighteen of their number to come to this Conference, and have only received acceptances from seven. As we were mostly to be found at the Exhibition just now, we thought it would be a good thing to have this Conference here. I have had a little experience as a rubber manufacturer during the past year, at least as an agent between the growers and the manufacturers. I think we all expect to get things a little too rapidly. Not only does the testimony of to-day show us that, but it has been demonstrated over and over again. But for a variety of reasons Hard Fine Para must continue to be used until we have convinced not only the manufacturers but the clients of the manufacturers that the new thing has come to stay and that it is equal to and possibly better than the old. All that must come in time, and we are proceeding fairly rapidly as it is. We had for a time a price above Hard Fine, but that was a time when plantation formed a very small proportion and now that our product forms a greater part of the total it has gone to the opposite extreme. We have the advantage or the disadvantage of living in one of the most conservative countries on earth. In America they rushed to take our stuff, and the consequence is that now the majority of the motor tyres in America are made from plantation rubber. On the other hand, there is only one manufacturer in this country who up to now has admitted that his tyres were entirely plantation. We know that most of them use plantation rubber, but we want to compel the public to ask for tyres made of plantation. About six or eight months ago, the Rubber Growers' Association offered to get made for the directors of rubber-producing companies some sets of motor tyres. We said we would get them made of any estate rubber that any director desired. We were successful in getting six manufacturers to express their willingness to make these tyres. I do not want to magnify difficulties or complaints, but the matter was certainly made very difficult for us, because when we went to place the orders with the manufacturers who had expressed their willingness, it was almost impossible to carry out our plan, certain manufacturers saying they would not make from smoked sheet, and others that they would not use unsmoked, while another would only make from biscuit. We were, however, successful in proving to certain manufacturers that they could produce a good motor tyre from something they had never used before. I think there has been no great fault to find with those tyres, and they have all been fairly successful. At all events, I have not yet had any complaint, and the demonstration has been very useful and satisfactory, inasmuch as it has shown to certain manufacturers that they can use a thing they have not been accustomed to using. I have no doubt that if we have a little patience we shall put our rubber into consumption in such a degree that it will to a large extent displace the demand for the high grade Para. On the question of handling our rubber, it is a significant fact that in all previous Exhibitions there has been a great deal of machinery shown. I think most of the people on estates are going to scrap their machinery, and the makers of machinery saw that in the circumstances they would do no good by exhibiting.

Mr. HODGMAN : I would like to say a word or two on behalf of the manufacturer in the United States. Apparently there is a good deal more conservatism here. My experience over there is that the manufacturers have learned very largely to adopt new methods and suit themselves to the change in circumstances. I know several large manufacturers who use practically no Para at all. In our own case, by adapting ourselves to the new conditions, we are eliminating the use of Para entirely. I think that is the general experience of the manufacturers. The object is to get absolute uniformity. When we can feel assured of uniform quality, of getting the same thing every time, there will not be much more use for Hard Fine Para rubber.

Mr. BOUSTEAD : Any remarks I was going to make have already been practically anticipated by the gentleman who said it was a question of supply and demand. The consumption of rubber increased enormously, and there was no increase in the supply of Hard Fine. Hard Fine costs double what ours costs to produce, and would be shut out of the market altogether if it were levelled down to plantation. I am wondering what effect the cost of production must have on certain rubbers.

Mr. A. BETHUNE : There is one way in which we can bring about a practical measure of uniformity, and that is by all the estates putting themselves under the Association's chemists in Ceylon and the Federated Malay States. Dr. Stevens has referred to the variation in the methods on estates, the number of times the crepe is put through the macerators, and so on. The easiest way to get the thing we want is for everyone not only to belong to the Rubber Growers' Association, but also to place themselves under the research scheme.

Mr. NOEL BINGLEY : I hoped to hear this afternoon a clear expression from the manufacturers as to whether there are or are not certain qualities in Wild Para, such as more nerve, due to the fact that the trees are 50 to 100 years of age or over. That is a very interesting point. I have been told by certain manufacturers that if one had a couple of motors of the same kind and put them to identical use, one being fitted with tyres made from wild rubber and the other with tyres made from plantation, the advantage would be all in favour of wild rubber.

Mr. W. H. HUGHES : I think I can answer that readily. I am interested in the manufacture of rubber, and our opinion is that the latex from the plantation tree is equally as good as that from the Brazilian tree. The difference is purely in the methods adopted in turning out the prepared rubber. The manufacturers have so far adapted themselves to the various qualities and grades of rubber from plantation sources that every pound of plantation rubber sent to this country has been used. Three or four years ago the manufacturers had practically no experience of plantation rubber. You sent your shipments along, and we adapted them for our use, but I must say that if the plantations could in some way prepare a standard rubber in the same way as Para is prepared we would like it very much indeed.

Mr. Bevis: It seems to me that the discussion this afternoon has turned rather in the direction of why you get less for your rubber than is paid for Para. That is to be answered by yourselves. You have a variety of plantations, and they do not make the same quality. You can better your conditions by getting a fairly standard quality. Manufacturers do not want to continue to pay more for Para if the plantation rubber is better. One trouble is that you do not come to the people who use your goods. You go to the brokers or dealers in the markets. Why not come to the manufacturers and say "here is our sample. Tell us what you want." If you do that, and try to achieve the standards that are most required, you will get nearer the price of Para than you are to-day. The manufacturers are accused of being conservative. They are conservative because they have to be. They are taking the risk, not you. When the rubber is manufactured we want to be sure that it is going to serve the same purpose that it has always served. Ask for the help of the manufacturers in arriving at a given standard, and then let all the plantations work for that standard, and you will get your better price.

Mr. P. J. Burgess: There is no way of determining the requirements except in the working. Often the same rubber varies in the vulcanisation.

Mr. Morrison: Mr. Burgess was a member of the Committee which investigated that matter, and showed without a doubt that vulcanising revealed the presence of chemicals in one case which were not found in another. Similarity of appearance, as you buy the rubber, does not lead to similarity of result.

Mr. Burgess: Do you not think there is an obvious corollary to that, and that the disadvantages arising from the variability of plantation rubber would be overcome by disclosure of such variations and an indication of their extent?

Mr. MacLulich: Although to the eye and perhaps to the hand quality may appear to be the same, the price fluctuates according to the demand for that particular brand of rubber. There is something in some brands that is peculiar and does affect the manufacture, and you will find that those brands invariably command a lower price than the brands which can be relied upon. There are at least forty brands, however, of which you can take any one and get the same result, provided you are careful in your manufacture. The reason certain people will not buy certain brands is that they cannot get sufficient to form what they call a consignment. Perhaps five tons of a particular brand comes on the market, perhaps only one ton. The difficulty can be got over by supplying your broker with the names of a number of different brands that turn out stuff that is fairly similar. From what we have heard here to-day one would imagine that you get no variation in wild rubber, but as a matter of fact it varies to a far greater degree than plantation. It varies in loss through washing, in dirt, in heating, and some of it in the end is much richer than other. The real bottom of it all is that the formula of the method of manufacture has to be altered in the mills.

Mr. Magor: With regard to the tyres made from plantation rubber, of which Mr. McEwan has told us, I would like to know if they were made from crepe. That would seem practically to answer the question whether crepe gives anything like the result required. If you go through the Exhibition you will be struck by the fact that there is just as much crepe as sheet being made—or all at events shown. And yet, we cannot help forming the idea that the manufacturer of crepe rubber should scrap his machines.

Mr. McEwan: All the tyres have been fully labelled. I would like to call the attention of the Conference to one exhibit near the rubber tennis court. On the stand of the Leyland and Birmingham Company are a number of goods made from pure plantation rubber only. We have been accustomed to hear of the various things for which plantation rubber is not useful, but we have now found some things for which only plantation is useful.

Mr. Morrison: Over eighty per cent. of our manufactures are now made from plantation rubber. I have stated that the brown crepe is cheaper; therefore we use it in preference to first latex. We believe the less the rubber is masticated the better it is.

The Chairman: I beg on behalf of the Council to thank our friends the manufacturers most sincerely for coming here to-day and telling us to some extent what they want.

Mr. Morrison: It would be better if you could go a little farther. Do you not think it would be wise to appoint three of your number to interview manufacturers. We have only just been talking round the subject, but if three of your number would meet a few of the manufacturers at a time it would be of great benefit to the planters and the manufacturers, too, I have no doubt.

The Chairman: We will certainly take your suggestion, and at the next meeting of the Council will probably nominate the three. I thank you very much.

The Conference then closed with a vote of thanks to the Chairman.

Part I.

CHAPTER III.

Names of Textile Plant Fibres.

By

LYSTER H. DEWEY.

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There are only about fifty different kinds of textile fibres of vegetable origin in the world's commerce, and less than twenty that are really important. The names of this limited number of objects should be such a simple matter as not to permit confusion. But, unfortunately, there is confusion now, and the careless use or misuse of names appears to be increasing. The lists of no two fibre brokers quite agree in the classification, or in the names used to designate fibres. But the brokers can scarcely be blamed, for no two authors who have written about texile fibres agree. Different authors have treated the subject from different standpoints. Botanists who have made careful studies of the plants in certain groups are too often accepted as authority for classification on other groups about which they have written but not studied. These and numerous other reasons and causes for the confusion in names are of minor importance, compared with the facts that confusion exists, that it causes annoyance, uncertainty, financial loss, and injury to trade, and that it may be remedied.

A manufacturing company in the United States purchased from India 1,200 tons of sunn, fibre of *Crotalaria juncea,* under the name "sunn hemp." The customs inspectors at New York noting the name "hemp" and the color of the fibre, similar to that of dew-retted Kentucky hemp, classified it as hemp and charged a duty of $22.50 per ton. After paying the import duty of $27,000 the importers protested, and then, after much delay and expense, obtained a correct classification from the Board of Appraisers, and it was entered free of duty.

A somewhat similar case occurred recently in exporting abacá (Manila hemp) from the Philippines to Japan. The misleading name hemp caused the Japanese customs inspectors to charge the hemp duty.

The name "hemp," with its various forms in the different languages, appears to be the oldest name used to designate a plant fibre. The Chinese name for hemp, ma 麻, was in use at least as early as the 28th century B.C. The English name hemp is traced back through Teutonic and Slav forms to an ancient Scythian or Caspian source, while the French *chanvre,* Spanish *cañamo,* and Italian *canapa* are traced through the Latin and Greek to the Sanscrit *cana* of prehistoric times. There is no question as to the priority of the name hemp, and in all languages this name and its cognate forms was first applied to the plant *Cannabis sativa* and its fibre. But, unfortunately, in nearly all languages this name, which should be restricted to one kind of plant and its fibre, is used as a kind of generic or group name for all long textile plant fibres, except flax, and, curiously enough, flax is the one fibre that most closely resembles hemp.

Henequén from Yucatan is called, outside of Yucatan, Mexican hemp or sisal hemp; sisal from the Bahamas is called sisal hemp; abaca from the Philippines is called Manila hemp, and this name is even applied to it when produced in Java, although the Javanese planters regard this as absurd, for it is neither hemp nor exported from Manila.

There is no necessity for the use of the term hemp as a synonym of fibre, and it should be restricted to designate the one and only true hemp and its fibre.

The name "sisal," which is less than 200 years old, is now being used to designate nearly all agave fibres, and even some fibres from furcraeas. Henequén, sisal, cantala, mescal maguey, cabuya, dispopo, zapupe, and other allied fibres, are all bunched together under the one name sisal, or, in some of the Government statistical tables, under the absurd designation "sisal grass."

The name "jute" is also being overworked and made to do duty for at least three or four different kinds of fibres produced by as many different species of plants. The two principal jute plants of India, *Corchorus capsularis*, and *Corchorus olitorius* are so nearly alike, and also their fibres are so much alike, that it may be well to retain the name jute for both, but it is unfortunate that it should be applied to ambari as "Bimlipitam jute" and to chingma as "China jute."

All will agree that there is need of some reform, and that if uniformity and clearness may be attained by any reasonable and simple method, such a method is worth considering. A list of names may be compiled by a committee of men familiar with the fibres in the market, in co-operation with men having an accurate knowledge of the plants producing the fibres.

An intricate code, like that governing the formation of botanical names of plants, is not advisable for the common names of fibres, but there are some obvious principles which should be considered in the choice of names.

(1) Names in most general use are to be preferred, provided they are not misleading.

(2) The same term should not be used to designate fibres from different kinds of plants.

(3) One name should be used to designate the fibre from one kind of plant, irrespective of the region where the plant is cultivated, or the manner in which the fibre is prepared. This term may be modified by geographic terms and terms indicating the character of the fibre; as Michigan dew-retted flax; Russian water-retted flax; Hawaiian machine-cleaned sisal; Bahama hand-cleaned sisal.

(4) Geographic names are objectionable for general terms; as Manila hemp grown in Java; Kentucky hemp in Wisconsin; Mauritius hemp in Natal or India.

(5) Names which may be directly adopted into all languages are desirable.

(6) Single words of not more than three syllables are best, because in most instances they will be used with geographic adjectives, or with terms indicating the character of the fibre.

A list prepared in accordance with these principles is here presented, not as an authoritative one, but merely as a check list which may be used by a committee of men familiar with fibres in the market, and also familiar with fibre-producing plants, in making up a list of names that may be adopted as authoritative.

The names in capital letters in the list, suggested as approved in accordance with the principles, are mostly names used by English-speaking people, though in some instances they are not the names most generally used. It is not supposed, however, that well-established names in other languages, like *Hanf* in German, *Lin* in French, *Canapa* in Italian and *Algodon* in Spanish, will give way in those languages to their English equivalents.

In the case of new or little known fibres for which there are no established names in commerce, there ought to be no serious difficulty in adopting one term for use in all languages.

The list presented makes no pretensions to be either complete or comprehensive. It merely contains the names most frequently seen or heard for the principal plant fibres of commerce.

This paper, which has been prepared in response to many suggestions in the form of errors and blunders, some involving financial loss, and some simply ludicrous, resulting from the confusion of names, is presented in the hope that it may lead to effective steps to clear away this Babel of confusion and establish a clear and definite authority for the names of commercial plant fibres.

CHECK LIST OF PRINCIPAL TEXTILE PLANT FIBRES AND FIBRE-PRODUCING PLANTS.

NAMES OF FIBRES.	COMMON NAMES OF PLANTS.	BOTANICAL NAMES OF PLANTS.	COUNTRIES OF PRODUCTION.
ABACA	ABACA	*Musa textilis* Nee.	Philippines.
Manila Hemp	Manila Hemp		Java.
Java Manila Hemp	Lanot		
Chanvre de Manille	Lanotan		
Manila-hanf	Pagua		
Manila Hennep	Utta		
Canapa di Manilla			
Cañamo de Manille			
Philippine Hemp			
Cebu Hemp			
Leyte Hemp			
Koffo			
AFRICAN SISAL (see Sisal)	Sisal	*Agave sisalana* Perrine.	
AGAVE			
(see Cantala)		*Agave cantala* Roxb.	
(see Espadin)		*Agave striata* Zucc.	
(see Guapilla)		*Agave falcata* Engelm.	
(see Henequén)		*Agave fourcroydes* Lem.	
(see Jaumave)		*Agave funkiana* Koch et Bouche.	
(see Mescal maguey)		*Agave pseudo-tequilana* Trelease.	
(see Sisal)		*Agave sisalana* Perrine.	
(see Tula)		*Agave lecheguilla* Torr.	
(see Tequila)		*Agave tequilana* Weber.	
(see Zapupe)		*Agave zapupe* Trelease.	
ALLAHABAD SUNN (see Sunn)	Sunn	*Crotalaria juncea* L..	

CHECK LIST OF PRINCIPAL TEXTILE PLANT FIBRES AND FIBRE-PRODUCING PLANTS.

Names of Fibres.	Common Names of Plants.	Botanical Names of Plants.	Countries of Production.
ALOE Mauritius Hemp Aloès Chanvre de Mauritius Chanvre pite Pite Mauritius-hanf Bombay aloe (in part)	ALOES CREOLE Aloës vert. Mauritius Hemp Giant Lily	*Furcraea foetida willemetiana* Roemer (*Furcraea gigantea* Vent.) (*Fourcroya gigantea* Spreng).	Mauritius. Natal. India.
AMBARI Ambari Hemp Bimlipatam Jute Deccan Hemp Gambo Hemp Java Jute Kottapotam Jute Madras Jute Saggy Sunn Shagi Can	AMBARI Ambari Hemp Ambadi Deccan Hemp Gambocanapa Gogunara Kanoff Mauve d'Algerie Mesta pat Nalita Palungo	*Hibiscus cannabinus* L.	India. Egypt. Persia. Java.
Benares Sunn (see Sunn)	Sunn	*Crotalaria juncea* L.	
Bengal Sunn (see Sunn)	Sunn	*Crotalaria juncea* L.	
Bimlipatam Jute (see Ambari)	Ambari	*Hibiscus cannabinus* L.	
Bombay Aloe (see Cantala)	Cantala	*Agave cantala* Roxb.	
Brown Hemp (see Sunn)	Sunn	*Crotalaria juncea* L.	
Cebu Hemp (see Abaca)	Abaca	*Musa textilis* Nee.	
CABUYA Cabulla Central American Sisal Costa Rica Sisal Cabulla de Costa Rica	CABUYA BLANCA Cabuya sin espina	*Furcraea cabuya integra* Trelease	Costa Rica.
Cañamo (see Hemp)	Hemp	*Cannabis sativa* L.	
CANTALA Manila Maguey Bombay Aloe	CANTALA Manila Maguey Nanas sabrang Ananas Boaya Kantala	*Agave cantala* Roxb. (*Agave americana* Blanco)	Java. Philippines. India.
Chanvre (see Hemp)	Hemp	*Cannabis sativa* L.	
Chapra Sunn (see Sunn)	Sunn	*Crotalaria juncea* L.	
CHINGMA China Jute Tientsin Jute	CHINGMA Indian Mallow Velvet Leaf Butter Print American Jute	*Abutilon theophrasti* Medic. (*Abutilon avicennae* Gaertn.)	China.
China Grass (see Ramie)	Ramie	*Boehmeria nivea* (L.) Gaud.	

CHECK LIST OF PRINCIPAL TEXTILE PLANT FIBRES AND FIBRE-PRODUCING PLANTS.

Names of Fibres.	Common Names of Plants.	Botanical Names of Plants.	Countries of Production.
China Jute (see Chingma)	Chingma	*Abutilon theophrasti* Medic.	
COIR	COCO PALM	*Cocos nucifera* L.	India.
Coco Fibre	Coconut Palm	*Cocos nucifera cupuliformis*	Java.
Coconut Fibre	Cocos Palm	*Cocos nucifera stuoposa*	Cochin China.
Cochin Coir	Kalapa	*Cocos nucifera rutila*	Malay States.
Ceylon Coir	Cocotier		
Kokosfasern	Cocos baum		
COTTON	COTTON	*Gossypium species.*	
Algodon			
Baumwolle			
Cotone			
Kapas			
Katoen			
American Upland Cotton	Cotton	*G. hirsutum* L.	United States. All cotton countries.
Georgia Cotton			
Texas Cotton			
Long Staple Cotton		*G. hirsutum* L.	United States.
Benders			
Delta Cotton			
Bourbon Cotton		*G. purpurascens* Poir.	
Chinese Cotton		*G. nanking* Meyer	China.
Egyptian Cotton		*G. barbadense* L.	Egypt, United States.
India Cotton		*G. arboreum neglectum* Watt.	India.
Japanese Cotton		*G. nanking* Meyer	Japan.
Levant Cotton		*G. herbaceum* L.	Asia Minor.
Kidney Cotton		*G. brasiliense* Macf.	Brazil.
Peruvian Cotton		*G. peruvianum* Cav.	Peru.
Sea Island Cotton		*G. barbadense* L.	United States.
Scinde Cotton		*G. stocksii* Mast.	India.
Courtrai (see Flax)	Flax	*Linum usitatissimum* L.	
CRIN VEGATAL	DWARF PALM	*Chamaerops humilis* L.	Algeria, Morocco.
African Fibre	Palmier nain		
Vegetable Hair			
Deccan Hemp (see Ambari)	Ambari	*Hibiscus cannabinus* L.	
Decra Jute (see Jute)	Jute	*Corchorus capsularis* L.	
*DESI JUTE	NALTA JUTE	*Corchorus olitorius* L.	India.
Daisee Jute	Ban pat		
Desi pat	Nutia		
Tosha	Sag		
Deswal Jute (see Jute)	Jute	*Corchorus capsularis* L.	
DISPOPO	COCUI	*Agave cocui* Trelease	Venezuela.
	Maguey de Cocui		
East African Sisal (see Sisal)	Sisal	*Agave sisalana* Perrine.	
East India Hemp (see Sunn)	Sunn	*Crotalaria juncea* L.	
ESPADIN	ESPADIN	*Agave striata* Zucc.	Mexico.

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* The name Desi (daisee) is probably used also to designate some fibre of jute, *C. capsularis.*

CHECK LIST OF PRINCIPAL TEXTILE PLANT FIBRES AND FIBRE-PRODUCING PLANTS.

Names of Fibres.	Common Names of Plants.	Botanical Names of Plants.	Countries of Production.
FLAX Linen Fibre Flachs Lin Lino Vlas Tisi Javas Katton Courtrai Irish Libau Pernau Pskoff Riga	FLAX Flachs Lin Vlas Hu ma Si-ao-ma	*Linum usitatissimum* L.	Russia. Belgium. France. Holland. Hungary. Ireland. Italy. Japan. United States.
Gambo Hemp (see Ambari)	Ambari	*Hibiscus cannabinus* L.	
German East African Hemp (see Sisal)	Sisal	*Agave sisalana* Perrine.	
GUAPILLA	GUAPILLA	*Agave falcata* Engelm	Mexico.
Hanf (see Hemp)	Hemp	*Cannabis sativa* L.	
Hawaiian Hemp (see Sisal)	Sisal	*Agave sisalana* Perrine.	
HEMP Canapa Cañamo Chanvre Hanf Hennep Hungarian Hemp Italian Hemp Russian Hemp Turkish Hemp American Hemp Kentucky Hemp	HEMP Asa (Jap.) Cañamo (Span.) Canapa (Ital.) Canep (Alban.) Canhamo (Port.) Chanvre (Fr.) Hamp (Swed.) Hampa (Dan.) Hanfbau (Ger.) Hennab (Arab.) Hennup (Dutch) Kanabira (Syr.) Kannab (Arab.) Kemp (Belg.) Kenevir (Bulg.) Konapli (Rus.) Konopj (Pol.) Ma (Chi.) Nasha (Turk.) Penek (Poli.) Tse-ma (Chi.)	*Cannabis sativa* L.	Russia. Hungary. Italy. Roumania. Servia. Turkey. United States. China. Japan.
HENEQUEN Sisal Sisal Hemp Sisal Grass Mexican Sisal Mexican Hemp Yucatan Sisal Yucatan Hemp Chanvre de Sisal Pita	HENEQUEN Sacci Sacque Sisal Sisal Blanco Weis Sisal	*Agave fourcroydes* Lem. (*A. elongata* Jacobi) (*A. rigida* Hemsley) (*A. rigida longifolia* Engelm) (*A. rigida elongata* Baker)	Yucatan. Campeche. Chiapas. Sinaloa. Cuba.
Huasteca Henequen (see Zapupe largo)	Zapupe verde	*Agave deweyana* Trelease.	

CHECK LIST OF PRINCIPAL TEXTILE PLANT FIBRES AND FIBRE-PRODUCING PLANTS.

Names of Fibres.	Common Names of Plants.	Botanical names of Plants.	Countries of Production.
Indian Hemp (see Ambari)	Ambari	*Hibiscus cannabinus* L.	
(see Jute)	Jute	*Corchorus capsularis* L.	
(see Sunn)	Sunn	*Crotalaria juncea* L.	
Istle or Ixtle (see Jaumave)	Jaumave lechuguilla	*Agave funkiana* C. Koch. et Bouche.	
(see Palma)	Palma zamandoque	*Samuela carnerosana* Trelease.	
(see Tula)	Lechuguilla	*Agave lechuguilla* Torr.	
Jarcia (see Zapupe largo)	Zapupe verde	*Agave deweyana* Trelease.	
*JAUMAVE (How-u-mah-ve) Jaumave Istle Jaumave Ixtle Mexican Fibre	Jaumave lechuguilla	*Agave funkiana* C. Koch et Bouche. (*Agave lophantha* Scheide).	Jaumave Valley, in Tamaulipas, Mexico.
Java Hemp (see Abaca)	Abaca	*Musa textilis* Nee.	
Java Sisal (see Sisal)	Sisal	*Agave sisalana* Perrine.	
(see Cantala)	Cantala	*Agave cantala* Roxb.	
Java Jute (see Ambari)	Ambari	*Hibiscus cannabinus* L.	
Jubbalpore Hemp (see Sunn)	Sunn	*Crotalaria juncea* L.	
JUTE Bengal Jute Calcutta Flax Gunny Fibre Hankow Jute India Hemp Juta Koshta Deora Jute Deswal Jute Naraingangi Jute Seraijganji Jute	JUTE Jews Mallow Jhut Pat Oi-ma	*Corchorus capsularis* L.	India. Japan. South China. Tonquin.
Lin (see Flax)	Flax	*Linum usitatissimum* L.	
Madras Jute (see Ambari)	Ambari	*Hibiscus cannabinus* L.	
Madras Hemp (see Sunn)	Sunn	*Crotalaria juncea* L.	
Maguey (see Cantala)	Cantala	*Agave cantala* Roxb.	
(see Cabuya)	Cabuya	*Furcraea cabuya* Trelease.	
(see Mescal Maguey)	Mescal Maguey	*Agave pseudo-tequilana* Trelease.	
Manila Hemp (see Abaca)	Abaca	*Musa textilis* Nee.	
Manila Maguey (see Cantala)	Cantala	*Agave cantala* Roxb.	
Mauritius Hemp (see Aloe)	Aloes creole	*Furcraea fœtida willemetiana* Roem.	
MESCAL MAGUEY Mazatlan Hemp	MESCAL MAGUEY	*Agave pseudo-tequilana* Trelease	Sinaloa, Mexico.

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* This name is not satisfactory, since it is a geographic name.

CHECK LIST OF PRINCIPAL TEXTILE PLANT FIBRES AND FIBRE-PRODUCING PLANTS.

Names of Fibres.	Common Names of Plants.	Botanical Names of Plants.	Countries of Production.
Mesta Pat (see Ambari)	Ambari	*Hibiscus cannabinus* L.	
Mexican Fibre (see Jaumave)	Jaumave lechuguilla	*Agave funkiana* C. Koch. et Bouchè.	
(see Palma)	Plama zamandoque	*Samuela carnesosana* Trelease.	
(see Tula)	Lechugüilla	*Agave lechuguilla* Torr.	
Mexican Hemp (see Henequen)	Henequen	*Agave fourcroydes* Lem.	
Mexican Sisal (see Henequen)	Henequen	*Agave fourcroydes* Lem.	
Natal Hemp (see Aloe)	Aloe	*Furcraea fœtida willemetiana* Roem.	
New Zealand Flax (see Phormium)	Phormium	*Phormium tenax* Forst.	
New Zealand Hemp (see Phormium)	Phormium	*Phormium tenax* Forst.	
Ortie de Chine (see Ramie)	Ramie	*Boehmeria nivea* (L.) Gaud.	
PALMA	ZAMANDOQUE	*Samuela carnerosana* Trelease.	
Palma Istle	Palma zamandoque		Mexico.
Palma Ixtle	Palma samandoca		
Samandoca	Yucca		
Zamandoque			
Mexican Fibre			
PHORMIUM	PHORMIUM	*Phormium tenax* Forst	New Zealand.
New Zealand Flax	New Zealand Flax		St. Helena.
New Zealand Hemp	New Zealand Hemp		France.
Huhiroa	Atiraukawa		
Huruhurukiki	Harakeke		
Korako	Ngutunni		
Muka	Oue		
Taihore	Rataroa		
Wharariki	Tihore		
PIÑA	Pineapple	*Ananas sativa* L.	Philippines.
Pineapple Fibre			Java.
Pita (see Pita floja)	Pita floja	*Ananas macrodontes* Morren	
(see Sisal)	Sisal	*Agave sisalana* Perrine.	
PITA FLOJA	PITA FLOJA	*Ananas macrodontes* Morren	Mexico.
Pita floya	Pita floya	(*Bromelia karatas L.*) (*Karavas plumieri* E. Morr.)	Central America
RAMIE	RAMIE	*Boehmeria nivea* (L.) Gaud.	
China Grass	Rhea (Eng.)		China.
Chu Ma	Ramio (Span.)		Japan.
Ramie Ribbons	Rameh (Dutch)		Taiwan.
Ramie Filasse	Mao (Japan)		
	Tchou ma (China)		
	Tsjo (Japan)		
	White-leaved Ramie		
RHEA	RHEA	*Boehmeria tenacissima* (Roxb.) Gaud	India.
	Green-leaved Ramie		Japan.
			Malay States.

CHECK LIST OF PRINCIPAL TEXTILE PLANT FIBRES AND FIBRE-PRODUCING PLANTS.

Names of Fibres.	Common Names of Plants.	Botanical Names of Plants.	Countries of Production.
Saint Helena Hemp (see Phormium)	Phormium	*Phormium tenax* Forst.	
San (see Sunn)	Sunn	*Crotalaria juncea* L.	
SISAL Sisal Hemp African Sisal Bahama Sisal Central American Sisal East African Sisal Java Sisal Pita Sisal Grass Sosquil White Sisal	SISAL Green Sisal Sisal Vert Sisal Verde Yaxci Yaxque	*Agave sisalana* Perrine (*Agave rigida sisalana* Engelm)	Bahamas. Caicos Is. Campeche, Mex. Chiapas, Mex. Curaçao. German East Africa. British East Africa. Hawaii. India. Java. Papua. Dutch Guiana. Fiji. Tripoli.
SUNN Sunn Hemp Brown Hemp Indian Hemp Conkanee Hemp Taag Bombay Hemp Dewghuddy Sunn Etarsi Sunn Gulburga Sunn Jubblepore Sunn Jubbalpur Hemp Philibit Sunn Sewnee Sunn Calcutta Hemp Allahabad Sunn Benares Sunn Bengal Sunn Chapra Sunn Madras Hemp	SUNN Pat San Sanai Sunn Hemp Phul Sunn Chun Pat	*Crotalaria juncea* L.	India.
Tampico Fibre (see Jaumave)	Jaumave Lechuguilla	*Agave funkiana* C. Koch et Bouché.	
(see Tula)	Lecheguilla	*Agave lecheguilla* Torr.	
(see Palma)	Palma Zamandoque	*Samuela carnerosana* Trelease.	
TEQUILA Maguey de Tequila	TEQUILA AZUL Tequila Maguey	*Agave tequilana* Weber	Jalisco. Mexico.
TULA Tula Istle Tula Ixlte Tampico	LECHUGUILLA	*Agave lecheguilla* Torr.	Mexico (North Central).
Turkish Hemp (see Hemp)	Hemp	*Cannabis sativa* L.	
ZAPUPE FINO	ZAPUPE AZUL Blue Zapupe Zapupe Estopier	*Agave zapupe* Trelease	Tamaulipas. Vera Cruz. Mexico.

CHECK LIST OF PRINCIPAL TEXTILE PLANT FIBRES AND FIBRE-PRODUCING PLANTS.

Names of Fibres.	Common Names of Plants.	Botanical Names of Plants.	Countries of Production.
ZAPUPE FUERTE	ZAPUPE DE TEPETZINTLA Zapupe Verde Zapupe Vincent Vincent Zapupe	*Agave lespinassei* Trelease	Tamaulipas. Vera Cruz. Mexico.
ZAPUPE LARGO Huasteca Henequen Jarcia	ZAPUPE VERDE Huasteca Henequen Zapupe de Tantoyuca	*Agave deweyana* Trelease	Tamaulipas. Vera Cruz. Mexico.

Fertilising Cotton in the United States.

By

OCKONOMICRAT E. LIERKE-BERLIN.

Cotton has long been, and will continue to be, the staple or chief money crop of the Southern farmer. In 1911, according to the latest available census report, the United States had 36,045,000 acres under cotton, producing a total crop of 15,692,701 bales of lint. One bale is about 500 lbs. gross weight, 478 lbs. net. The cotton crop for the same year was valued at 732,420,000 dollars, while the seed in the raw state from such a crop would alone be worth over 100,000,000 dollars. The world's cotton supply for 1911, as far as statistics go, was 23,421,055 bales, which means that the United States produce about 67% of the total world's supply. Of the total acreage under cotton, Texas contributes 10,943,000 acres, or a little over 30%, while Georgia comes next with 5,504,000 acres, or about 15%.

There was a time when all that the cotton farmer did in order to grow more cotton was simply to clear new land and plant more acres. This was an easy matter with him, as land was cheap and labour plentiful. But to-day conditions in the Cotton Belt are very different. Land has become so valuable and labour so high that it is imperative upon every farmer who grows a profitable cotton crop to make one acre perform the work that was formerly required of two or three acres. It is now a matter of " not more acres, but better acres." It is within the power of every farmer to build up his land until every acre is a profitable acre, and the marked progress that has been made by the cotton planted towards this goal within the past few years shows what can be accomplished when correct and improved methods are adopted. In the words of a distinguished Southern agriculturist, " There is a new spirit abroad in the South, and the day is not far distant when a farmer will be ashamed to tell you that his land is poor, for our people are fast coming to understand that if a man's land remains poor it is the fault of the man who farms it."

Throughout the great Cotton Belt diversified farming is making rapid progress, and intensive methods of cultivation are being practised. The progressive cotton grower is not satisfied to make a large crop at a sacrifice of his soil fertility, but he is adopting improved methods in his farming operations with a view of increasing the yield per acre and at the same time leaving his land in a high state of fertility. According to statistics of the United States Department of Agriculture, it now requires on an average 2½ acres to produce one bale of cotton. Notwithstanding this fact, it is being demonstrated every year by many practical farmers that by thorough preparation of the soil, proper rotation of crops, careful seed selection, good cultivation and liberal fertilization, the yield of cotton can profitably be increased to such an extent that one bale per acre is not unusual.

Before entering into a discussion of the manurial question, a word or two on the cultivation of cotton in the United States may not be out of place. Cotton can be grown successfully on a variety of soils ; in fact it flourishes in most of the Gulf States on sand, clay, sandy loam and peat. The best type of soil, however, for successful cotton growing is a light clay loam or a medium sandy loam.

Rainfall and General Cultivation.

The rainfall has a considerable influence on the cotton crop. A good soil should maintain uniform conditions of moisture. A heavy clay soil, unless exceedingly well drained, is apt to retain too much moisture, and conditions are set up whereby the cotton plants are rendered very susceptible to disease. Sandy soils again are apt to be too dry and unretentive, and require a good deal of liming or green manuring to bring them into good mechanical condition.

The usual method of cultivation is to plough 6 to 8 inches deep, according to the nature of the soil. In the case of heavy soil, ploughing should be carried out during early winter, so that the frosts may penetrate to a good depth and ensure the soil being well opened when the thaw comes. With lighter soil, ploughing should be done just before planting. Where the land is rather rough, it should be run over once or twice with a harrow to ensure a good seed bed. Three weeks before planting time, the land should be laid out in rows from 3 to 4 feet wide, the fertilizer distributed in the furrows and a scooter plough run in to mix the fertilizers well with the soil. It is then ready for the last drilling up before seed planting.

Seed Selection.

This branch of cotton culture in America is receiving more and more attention, and rightly so. No amount of judicious manuring will benefit a crop springing from bad seed, therefore every intelligent grower, whether a cotton grower or any other kind of grower, ought to devote much care to the selection of his seed, with a view to maintaining and increasing the productiveness and also the quality of his crop. Always select the best bolls from the best and healthiest looking plants, and store these carefully, taking the precaution to note all particulars as to parentage, number of bolls on the plants, total weight, and if possible the percentage yield of lint. It will then be an easy matter to select the bolls from the best seed-mothers at planting time. These particulars may appear to the average grower as unnecessary palaver, but he will find that when he puts it into practice it will pay in the end, by increasing the yield and giving better quality and freedom from disease.

Plant-Foods.

The cotton plant is rather a heavy feeder, and requires a soil well stored with readily available plant food. The plant foods, nitrogen, phosphoric acid and potash, of necessity should all be present in soluble form to be of direct use to the plant. All fertilizers for cotton should contain the three essential ingredients. It is also necessary that these three ingredients should be present in the correct proportions. For instance, if sufficient phosphoric acid and nitrogen be applied, and insufficient potash, then the crop will not come up to expectations. The nitrogen element is essential in the production of the green parts of the plant, such as the stem and leaves, but excess will retard the production of flowers and buds. If a plant is provided with as much available nitrogen as it can use at flowering time, the formation of flowers may be checked and all growth transferred again to promote leaf and stem growth, increasing at the expense of seed and lint. That a large proportion of phosphoric acid in the cotton plant is to be found in the seed, will be sufficient to prove the importance of this ingredient for the crop under discussion. Phosphoric acid hastens the maturity of plants, and promotes the formation of albuminoids in the seed. Potash is another ingredient essential to the formation and transference of carbohydrates in the plant. Thus all the vital processes going on daily in the plant depend upon the presence of sufficient potash. Potash has also an important function to play in the development of the woody parts of stem, roots and branches.

FERTILIZING COTTON.

The marked progress that has been made in the intelligent use of fertilizers by cotton planters in America is largely due to the good work of the agricultural colleges and experiment stations. Small applications of 200 and 300 lbs. per acre of low grade fertilizers of the 8-2-2 type (8% available phosphoric acid, 2% ammonia, and 2% potash), are no longer tolerated by the successful cotton farmers, and anyone who is so far behind the times as to be guilty of such a practice to-day is more to be pitied than censured. High grade fertilizers and heavier applications per acre are rapidly coming into favour by cotton growers. Among the most common fertilizers for cotton are the 8-3-3, 8-4-4, 9-3-3, and 9-4-4 mixtures used at the rate of 400 to 800 lbs. per acre, depending upon the character and condition of the soil.

Land in a poor state of fertility, deficient in organic matter and broken shallow will not respond to heavy quantities of fertilizers unless used in small and frequent applications, while the amount that can be used on land of good tilth is only limited by the line of profitable crop production. Dr. B. W. Kilgore, State Chemist and Director of the North Carolina Agricultural Experiment Station, says: "We have found in our experimental work, which has been running for a number of years, that with the use of 800 to 1,000 lbs. of a good fertilizer, not merely on our experimental plots, but upon the fields on which we are growing cotton on considerable areas, we are able to get one bale per acre. Applying this to our general farming conditions (and the soils upon which we are operating are no better than the average North Carolina soils), we readily see that with the use of the amount of fertilizers referred to above, we could produce our cotton crop of practically one million bales on a million acres of land, and have one-third of our time and land to devote to something else, or upon which to grow soil-improving or feed crops."

With heavy applications of fertilizers on cotton, it is becoming a common practice to use one-half of the fertilizers before planting the crop, and the remainder in one or two applications during the cultivation. Dr. R. J. H. DeLoach, Director of the Georgia Experiment Station, says: "Almost every Agricultural Experiment Station, where commercial fertilizers have played any part in the experimental work, recommends the second application. The great success with which the young boys of the South have met in the corn club work, proves very clearly the importance of making the second and even the third application of fertilizers. Not many of the contestants put all the fertilizers down in the soil before planting, and every prize winner up to the present time has made two or three applications of one or all plant foods used in making the crop." The mixtures generally used for top dressing or as side applications during the cultivation of cotton run from 4 to 5% available phosphoric acid, 5 to 7% ammonia, and 3 to 5% potash. A very popular form of side application coming into use among the cotton farmers of the sandy regions is a mixture of equal parts of kainit and nitrate of soda applied at the rate of 200 to 400 lbs. per acre.

The boll weevil, which has caused considerable damage to the cotton crops of Texas, Louisiana and Mississippi, is slowly but surely extending its field of operations until it is only a question of time, when it will be at work in every State in the Cotton Belt. The United States Government has spent millions of dollars trying to find some means by which it could protect the cotton industry from the terrible ravages of this pest. After years spent in studying the habits of this insect, and after careful experiments, it has been found that we must depend largely for our success in growing cotton under boll weevil conditions upon getting our crops to mature as early as possible. Such a condition must be brought about by planting an early variety of cotton, fertilizing it properly and liberally, and giving it frequent and thorough cultivation. This only emphasizes the importance and necessity of providing the cotton crop with a liberal supply of plant food in order that it may get an early start in its race against the boll weevil.

On many light and sandy soils, cotton is subject to blight or "rust," which often reduces the yield to an unprofitable basis. It has been found by experiment that potash is a preventive of blight or "rust" in cotton. The Alabama Experiment Station says: "In our co-operative fertilizer experiments, 100 lbs. of kainit per acre has been repeatedly contrasted with 200 lbs., both being used in connection with cotton-seed meal and acid phosphate. The smaller as well as the larger amount has exercised a noticeable effect in checking "rust." In 1898, on the Station Farm, 200, 100 and 60 lbs. of kainit per acre were compared, each forming part of a complete fertilizer. The largest amount was most marked in its restraining effect upon rust, while 60 lbs. exerted a slightly favourable influence. If kainit is used to prevent rust, it seems advisable to use at least 100 lbs. per acre, and quantities much smaller than this can scarcely be expected to have much effect on rust, though in a general way they may be beneficial. In 1898 muriate of potash, at the rate of 50 lbs. per acre, was at least as effective as 200 lbs. of kainit in restraining rust and in augmenting the yield. Black rust was very severe on the plots receiving no potash, and on the plot to which had been applied, in large quantity, an insoluble form of potash—native feldspar rock. In checking rust 200 lbs. of kainit per acre was better than 100 lbs., and this latter amount was slightly more effective than 60 lbs. of kainit per acre." The Mississippi Experiment Station, in Bulletin No. 135, giving results of fertilizer experiments on cotton, states: "Next to manure in increasing the yield stands kainit, or the combinations in which kainit is used. The evident benefit from kainit was probably due to the fact that cotton is very subject to rust on this particular piece of land, and the kainit prevented the rust."

During the past season a number of successful farmers throughout the Cotton Belt carried out experiments for the purpose of testing the value of potash as a fertilizer for cotton. These experiments in most cases consisted of three plots, as follows :—

Plot No. 1.—Not fertilized, but used as a check plot.
Plot No. 2.—Fertilized with phosphoric acid, nitrogen and potash.
Plot No. 3.—Fertilized with phosphoric acid and nitrogen, only the potash omitted.

On the control of the rust disease, a net profit of 23.65 dollars per acre was had by applying 200 lbs. of kainit as a top dresser to cotton which had been previously fertilized with a 400 lbs. application of a mixture analysing 10% available phosphoric acid, 2% ammonia, and 4% potash. The effect of kainit as a profitable application for rust control is thus clearly demonstrated, and its use has become an absolute necessity for maximum crop production in many sections of the Southern States.

In an experiment on cotton by Mr. J. L. Brake, Rocky Mount, N.C., rust appeared in one of the plots which had been fertilized with phosphoric acid and nitrogen only, and the yield gathered from this plot was at the rate of 350 lbs. of seed cotton per acre. On an adjoining plot, on identical soil, where potash was used in addition to phosphoric acid and nitrogen, the yield was at the rate of 1,000 lbs. of seed cotton per acre. An analysis of Table No. IV. will show how profitable it was for the cotton farmer to use potash in his fertilizer mixture.

By the addition of 240 lbs. of kainit per acre to the other fertilizers used, the yield of seed cotton per acre was increased all the way from 384 to 894 lbs., or an average increase from ten experiments of 537 lbs. of seed cotton per acre from the potash alone. In other words, for every lb. of kainit used there was an increased yield of over 2 lbs. of seed cotton. Now 240 lbs. of kainit at 14.00 dollars per ton is worth 1.68 dollars. The increased yield from the use of this amount of kainit was 537 lbs. seed cotton, equal to 179 lbs. of lint, worth 17.90 dollars, leaving a profit of 16.22 dollars from an investment of 1.68 dollars in kainit. By the addition of 96 lbs. of muriate of potash to the other fertilizers used, the yield of seed cotton per acre was increased all the way from 120 to 590 lbs., or an average of 247½ lbs. of seed cotton per acre, there was increased yield of over 2½ lbs. of seed cotton. The 96 lbs. of muriate of potash is worth 2.30 dollars. The increased yield from this amount was 247½ lbs. of seed cotton, equal to about 82 lbs. of lint, worth 8.20 dollars, leaving a profit of 5.90 dollars from an investment of dollars 2.30.

Not only was the profit made, but the cotton held its leaves and was in good condition during the latter part of the season. All the mass of vegetable matter was thus held so as to be ploughed under in the fall, and with the impoverished soil of the Cotton Belt this fact is no small item in the matter of soil fertility.

FACTORS THAT INFLUENCE THE LENGTH, STRENGTH AND QUALITY OF COTTON FIBRES.

The value of cotton is dependent upon the length, strength and quality of the fibre, and there are quite a number of closely related factors that have a marked influence upon these qualities, which for convenience may be grouped as follows :

I. Hereditary and acquired characteristics.
II. Climate, soil, fertilization and cultivation.
III. Diseases and insects.
IV. Handling and grading.

I. Hereditary and Acquired Characteristics.

As the parent stock largely determines the characteristics of its progeny, plant breeding and selection play a very important part in profitable cotton production. Many cotton farmers do not give proper consideration to these factors, but are content to plant impure, mixed and inferior seed, with the results that the yields are unsatisfactory and the fibre of a poor quality. By careful attention to plant breeding and selection, the length, strength and quality of the cotton fibre can be improved to a considerable extent, and the increased value of the cotton will more than repay for the time and trouble given to the work.

II. Climate, Soil, Fertilization and Cultivation.

Cotton is influenced more than any other staple crop in the United States by climatic conditions. Being a native of the tropics it must have for its most profitable production a long growing season with relatively high temperature and abundance of sunshine, a normal rainfall distributed throughout the growing season, with a moderate quantity at the time of maturity. These conditions are found to an admirable extent in the Great Cotton Belt of the United States, which makes this region an ideal home for the cotton plant. Cold weather in the spring retards growth, heavy rains during the growing season cause a production of " weed " or foliage, at the expense of fruit development, promote the growth of grass, and makes thorough cultivation difficult ; drought stunts the plant and causes early maturity and a consequent reduction of yield, while early frost kills the plant, reducing the yield and causing short, weak and low-grade fibre from immature bolls. High temperature, plenty of sunshine, and moderate rainfall well distributed are ideal conditions for the production of lint of the best quality, *i.e.*, long, strong and silky fibres. Moderate rainfall at the time of maturity has a tendency to cause a whiter and cleaner lint. Cotton will adjust itself to soil conditions, and there is no one soil which is typical of the Cotton Belt. The character and condition of the land, whether it is a stiff clay or a light sandy soil, whether rich or poor, play a very important part in the yield and quality of the crop.

Dr. Herbert J. Webber, in an article on " The Growing of Long-staple Upland Cottons," published in the Year Book of the United States Department of Agriculture for 1903, says—" In the alluvial delta region of Mississippi and Louisiana, where long-staple cottons first came into prominence, the soil is very rich and does not require artificial fertilization to give good yields. One peculiarity of the fibre grown on such soils is its greater length and fineness as compared with that of the same variety grown on the poorer soils of the hill regions. This feature is one commonly observed by growers. The better and richer the soil the longer and finer the fibre. Soils artificially manured also show the same effect in the quality of the fibre." He further states—" The fibre of the long-staple upland varieties is also rather low in strength, and this is another feature that must be improved before they will be perfectly satisfactory. Different individual plants vary greatly in strength of lint, and there can be no doubt that stronger fibred varieties can be produced. Some varieties under certain conditions will produce strong fibre, and under other conditions weak fibre. It is probable that the nature or composition of the soil and of the fertilizer used has much to do with this character, but the knowledge now possessed is not sufficient to allow of definite statements. It is a general belief that staple produced by plants grown on light, sterile soils, is weaker than that produced by plants grown on rich soils. The correctness of this statement is doubtful, however, as the writer has found sterile fields producing stronger fibre, while the rich delta lands of Mississippi, planted with the same variety, gave a fibre generally low in strength. The writer is aware that strength in cotton fibre is relative. What is strong for a long-staple upland would be weak indeed for a Sea Island or Egyptian. Many times, in discussions with cotton buyers regarding the strength of long-staple upland cottons, he has found that their knowledge is based on a comparison of locally grown sorts only. There can be no question that, as a group, the long-staple uplands are weak in fibre, and that varieties with uniformly stronger fibre are much to be desired."

To what extent phosphoric acid, nitrogen and potash, as plant foods, influence the length, strength and quality of the cotton fibre is not yet definitely known, as very little study and attention have been given to this line of investigations. This is a fruitful field of research for our Agricultural Experiment Stations, and as the cotton crop is of such great commercial importance to the world and the value of the lint is dependent upon the length, strength and quality of its fibre, every effort should be made by the agricultural experiment stations to study every factor that exerts an influence on these qualities with a view of improving the fibre, thereby making the cotton crop more valuable.

It is known that phosphoric acid hastens the maturity of cotton, while Potash keeps the plant in a green and growing condition throughout the season—a condition which is said to favour the production of a longer and stronger fibre. Nitrogen in small amounts and in combination with phosphoric acid favours early maturity, but used in excess causes "weed" growth at the expense of fruit and retards the opening of cotton.

During the year 1913, samples of cotton were collected from 44 fertilizer experiments conducted by the German Kali Works, and the tensile strength of the fibre tested by the South Carolina Agricultural Experiment Station. Out of the 44 experiments, eleven experiments or 25 per cent. showed the strongest fibre from the O or "no fertilizer" plots ; fourteen experiments, or 31 per cent. the strongest fibre from the PN or "phosphoric acid and nitrogen plots" ; while nineteen experiments or 43 per cent. showed the strongest fibre from the KPN or "Potash, phosphoric acid and nitrogen plots." While the figures indicate that Potash favors a stronger fibre, these tests are the results of only one season's experiments, and as the climatic conditions were unfavorable in many sections, it will be necessary to continue this work before any definite conclusions can be made.

The results are given in the following tables showing the tensile strength of the cotton fibre in grains.

Table V.—Giving strongest fibre from O Plot.
Table VI.—Giving strongest fibre from KPN Plot.
Table VII.—Giving strongest fibre from PN Plot.

III. Diseases and Insects.

Cotton that is diseased or attacked by insects produces a poor quality of fibre on account of the weak condition of the plant. The tissue of the fibre is often destroyed, while in every case the lint is more or less stained or discolored, and further lowered in grade by becoming mixed with leaves, stems and other trash.

IV. Handling and Grading.

The manner in which cotton is handled plays a very important part as far as the quality of the cotton is concerned. In the hands of careless pickers the seed-cotton becomes mixed with the dead leaves, stems, burrs and other trash, some of which passes through the gin with the lint, lowering its grade or quality. Cotton is sometimes left in the field for weeks exposed to the deteriorating effects of rain and sun, which cause a harsh, weak lint with loss of bloom or color.

In grading cotton first consideration is given to the amount of trash it contains, although other factors such as color, bloom, length and strength of staple, and the percentage of gin-cut or broken fibres play important parts.

The Chairman: What is this fertilizer to which you allude, this Kainit?

Dr. Leirke: It is a potash.

The Chairman: Can you tell us where the cotton boll weevil came from originally?

Dr. Lierke: It came first from the Western States and went to the Eastern States. It is about four millimetres long.

Dr. Pickles: I think this is a very interesting paper for us to have heard, from the point of view that there is a close connection nowadays between rubber and cotton. The Industry represented by many of the delegates here is essentially rubber, but at the same time cotton is intimately connected with it in many productions, such as hose and tyres, in which it plays a very important part. The cotton boll weevil is one of the most dreaded of the pests, and it is very interesting to know that fertilizers can get the better of the boll weevil by accelerating the crop. With a further study of this matter we should have plantations of cotton just as there are plantations of rubber, for special purposes.

The Chairman: It would also be a bit interesting to see how far the connection between the type of fertilizer and the resulting fibre, and likewise the nerve of rubber, could be carried. What kind of staple do you require?

Dr. Pickles: We want a long staple and very strong. Probably the motor tyre industry takes the very best quality of cotton produced. The price paid is as much as one would expect to pay for silk. From that point of view the improvement of the cotton crops is particularly connected with our own industry of rubber.

Dr. Lierke: We are going into the matter quite closely for next season. We have discussed the matter with manufacturers, and all agree that it is absolutely necessary to have a cotton of high quality in tensile strength and heat resisting power. Heat destroys the fibre, and when you see a motor tyre that has broken, it is always the cotton that has broken. Work in the manuring of cotton to produce a very fine heat resisting kind is very important for both the cotton and the rubber industries.

Mr. Ewart Barbary: I should like to say a few words, as one who uses some 88,000 lbs. of cotton a week in the explosives industry with which I am connected. This matter of the effect of fertilizers on cotton requires very careful attention. Not only the length and the strength of the fibre has to be considered, but in connection with the motor tyre industry the heat which cotton can stand has a great deal to do with its structure. I have had a great many experiments made so far as nitrate cottons are concerned, and the fact that were highly manured has destroyed their usefulness altogether.

The CHAIRMAN : Where does that defect come in ?

Mr. EWART BARBARY : It comes in the nitration. The absorption of the cotton in the nitro-process is more sluggish. It certainly seems to me that we have not only to look to length of fibre and strength of fibre in the case of the motor tyre industry, where the conduction of heat is concerned. I have had a lot to do with experiments in the conduction of heat, and there is a wonderful difference in the way the grades of cotton will conduct the heat from gutta percha, etc. A highly manured cotton breaks more frequently than that containing real properties of gradual growth. You get length of fibre and strength of fibre, but you lose other properties.

Dr. LIERKE : Is the speaker quite assured as to the genuineness of the cotton with which experiments have been made ? I do not think any Liverpool broker will tell him how the cotton was produced. This is perhaps a result of the prejudice that we often have to combat. When objection is made that highly-manured cotton is of bad quality I cannot believe it until I have seen the proper tests under conditions which make us quite certain how the fibre has been grown. We must make sure that the plant has had all the proper chances, that it is of good stock to begin with, that the fertilizer used is a good one, and that there has been no interruption in the growth through bad weather or other causes. Otherwise the fibre cannot be considered of good quality. I believe that everything depends on the purity of the carbohydrates, and that a well manured cotton must always result in a good product. I will be obliged if the gentleman who has spoken of this subject will make his tests on cotton grown on certain land and with good manures.

Mr. EWART BARBARY : I have a friend who is a planter, and for three years he sent samples for experimental purposes. The experiments have been carried on between the two of us. The fibres were cultivated with patent manures. Nitrogen had been given in one plot, and nitrate and magnesium salts and potassium salts in another plot, and for experimental purposes phosphoric acid was employed. Magnesium salts proved to be the worst. This subject has come suddenly under my notice this afternoon, but I believe that to be the case. I wanted light thrown on the matter for my own information.

Problems of the Future Conditions of the Palm Oil Industry.

By

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The important concessions obtained during the last few months by various English, French and German companies (which are actually seeking to transfer to African soil their factories for the extraction of oils), and the interest now taken, especially in Germany, in all economic and technical questions relating to oleaginous products, show clearly that a new era is commencing in the palm oil industry. The revolution which is taking place under our eyes is bringing to light problems of the greatest moment, which it is necessary to solve in accordance with the progressive evolution of the industry.

The following are some of the problems which I propose to discuss with you :—

BOTANICAL AND BIOLOGICAL QUESTIONS.

The oil palms, *Elæis guineensis* Jacquin, are not necessarily identical with one another, and it is universally known that a large number of varieties exist which have already attracted the attention of numerous observers. Notwithstanding the great efforts already made by men such as M. Auguste Chevalier, M. P. Preuss and M. Soskin (to mention no others), the question of the diversities of oil palms still remains obscure, equally as regards their botanical identification and from the point of view of biology. At present, a certain number are clearly differentiated by the character of their fruit, without it having been possible to characterise them by any characters of their vegetative parts. This renders difficult the dividing of the various species of the *Elæis* into perfectly distinct groups. It provides a problem of the very first importance which remains to be solved.

For the guidance of those who are interested we will limit ourselves to the consideration, with M. Beccari, of the fact that the forms now known to exist may be grouped as follows :—

1. The purely primitive forest species, difficult to define, but which we may characterise as being thick shelled and as having a very

vigorous growth and producing fruit with a moderate amount of pulp and large stones.

2. The species obtained by cultivation or domestication, bearing fruit of abundant pulp and having a thin-shelled kernel.
3. Growths intermediate to the above two classes.
4. Abnormal or pathological species.

Taking the second group, two species are particularly interesting, the first of which is the Votchi variety, of Dahomey (*Elæis nigrescens* A. Chev. var. *pisifera* A. Chev.). This variety bears an elongated fruit with thick pulp and a shell composed of more or less hard fibre in greater or less degree closely compressed, with a very small kernel the size of a pea. Experience shows that this variety is of the greatest economic value on account of the abundance and rich quality of the pulp.

Another variety deserves our attention for a moment, viz., the Ceredi species, of the Ivory Coast (*Elæis nigrescens* A. Chev. var. *ceredia* A. Chev.). This species also has a thin shell, but there is another peculiarity which makes it interesting. Side by side with the normal fruit-bearing seeds, there are spadices carrying smaller fruit which have not been fertilised, and which are absolutely without seed. This unfertilised fruit exists in very many varieties, but in small quantities, whereas in this species two-thirds of the fruit present the peculiarity, and, moreover, they attain almost the same size as the normal fruit. These parthecocarpic fruits consist of an oily pulp, in the heart of which there are some rigid fibres which represent what would be the kernel. The multiplication of these species would therefore seem to be advisable, but this brings us to the consideration of the biology of oil-producing palms, and here also we are forced to acknowledge that we know but little. A great effort will have to be made to determine whether the different species of oil palms are of permanent type before we attempt to multiply them be seeding operations, or whether the hope of reproducing them with certainty must be abandoned. What makes these researches especially difficult is the necessity of waiting several years until the palms bear fruit; and also the irregular germination of the seed, the sole means of propagating the trees.

The first thing to be done is to find a way of hastening the germination of the seed, and above all, of making the germination regular. Another necessity is that of discovering, by a careful study of the anatomy of the leaves of these trees, correlative characteristics which will permit us to determine to what variety the young plants, not yet bearing fruit, belong. In short, the biology of the oil palm is still little known, and we have yet to discover the principles of its cultivation.

TECHNICAL PROBLEMS.

It is not sufficient to be in possession of the palm fruit, but also to obtain from that fruit the oil which represents the highest commercial value. The modern process of hydrogenation, which permits of the oil of the palm being rendered edible when not too acid, will certainly expedite the evolutionary steps of which we have spoken previously. The industry is on the look out for oils capable of being commercially treated by a settled class of machinery, and therefore it is of the highest necessity that a commercial classification of palm oils should be made, to replace the terminology of origin now in use. This is what is proposed by the Commission for Oleaginous Products of the German Colonial

Wirthschaftliches Committee in expressing the wish that the oils containing 8 per cent., or less, of acid should be classified under the denomination of comestible oils (that is to say, which may be rendered comestible by hydrogenation).

The necessity thus imposed by industrial conditions forces the producers to export a standard quality. Consequently they must produce always the same kind of fruit in bulk, and must replace the native methods of treatment by modern improved methods and the aid of improved material in the country of origin itself. This seems to have been well understood by the organisers of the undertakings of which we spoke in the beginning, and, in spite of the mystery with which the manufacturers have surrounded their improved appliances, it appears that at the present moment this problem has actually been solved from many sides.

On the other hand, the question of the standardisation of the fruit itself is not by any means solved, and it seems probable that in the very near future the exploitation of the indigenous stocks of oil palms will have had its day, and will give place to the cultivation of selected species; which brings us back again, by a different path, to the biological problems which we began by discussing.

ECONOMIC PROBLEMS.

We are here touching upon an extremely delicate point in the history of the oil palm, that is to say, the question of the proprietorship of the natural palm groves. At the present time the natives are more more or less engaged in cultivating these palm groves, but it is very rarely that they do not claim the proprietorship of the areas. Therefore the rush for the cultivation of the groves presents certain difficulties, which, in some cases, have been more or less settled. This is a new and strong reason why it would be preferable to take up definitely the undertaking of plantations.

CONCLUSION.

At the moment the question of oil palms is complicated by the fact that Africa will no longer be, in the near future, the only part of the world producing these fruits. If our information is correct, extremely important attempts are now being carried out in Sumatra in establishing plantations of the *Elæis*. If this experiment succeeds we shall therefore have to reckon with the production of oil palms which will be run as an annexe of rubber plantations, without competing with a superior quality. It does not seem to us that the African producers need be very much alarmed if, as certain amongst them appear to have decided upon, they will undertake a regular yearly construction upon a rational basis of plantations of oil palms side by side with their indigenous palm groves—complying with all the conditions which we have just enumerated, and with the collaboration of scientists attempting to solve some of the problems which present themselves in connection with the economic future of the palm oil industry.

The CHAIRMAN: This is rather a new subject for us, and I am sure a number of questions will have occurred to the Conference on which they would like information. I have no idea as to the rapidity of the growth of the oil palm.

Dr. GATIN : In Africa the oil palm can produce after seven years.

The CHAIRMAN : How large will the tree be at that time ?

Dr. GATIN : At that time it is not very high. The fruit can be cut quite easily. But the plantations in Sumatra produce more quickly. After five years they will give a good production.

Mr. BAXENDALE : How does the quantity of this production compare with others ?

Dr. GATIN : Certainly the use of palm oils will become larger when the hydrogenation process has been made, but it is necessary to standardise the oil palm industry, classifying as palm oils those containing 8 per cent. fatty acids. Palm oils can be transformed into edible palm oils after hydrogenation, and in this way the oil can gain a more extensive market.

Mr. STAFFORD WHITBY : In Sumatra some time ago I found that there was a great amount of interest in oil palm planting. There were many nurseries, and much planting was going on. I can confirm that a general hope was held at least that they were going to get a yield after five years. Can the reader of the paper give any us definite figures as to the yield per acre in Africa ? I should further like to know whether the method of extracting the oil from the kernels has been by expression, or whether solvents have been tried ?

Dr. GATIN : The best results, if I am well informed, have been by pressure. I know that in Cameroon the German people have perfect machinery for palm oil extraction, but this machinery is not known outside ; the company employing it keep it very secret. I think, from what I can learn from people who have seen the machinery, that the best results were obtained by the dry process, which is based upon the principle that if you press the entire palm oil fruit, that is to say the kernel and the pulp, you obtain the same quantity of oil as when you press the pulp alone. It is important not to let water go into the matter, as it is through the pulp becoming too wet that the greatest amount of fatty acids develops. When the entire fruits are pressed in this way, it is easier to separate the kernels from the already dried pulp. Afterwards you can obtain a second lot of oil. As to the other question about the yield per acre of this oil product, I have no very definite information, because the various authors who have written on this subject differ entirely one from another. I am only able to tell you what I have heard, but I hope that the yield of the oil palm in Africa will be such as to become very profitable, both in the extraction of the oil and in the utilisation of by-products, which should be sufficient to pay the expenses.

Mr. KOENIG : I would like to ask what use is made of the oil cake in Africa. Is there a large export, or is it used for cattle feeding ?

Dr. GATIN : I have not collected much information, but the oil palm industry in the European manner is not very old. I do not remember whether experiments have been made regarding the feeding of cattle.

Mr. LEPLAE : The fruit of the oil palm is composed of two parts, the kernel and the outside pulp. When that pulp is treated, it gives oil but no cake. Only the kernel gives cake. That cake is produced in Europe only, and not in Africa. In Europe it is very largely used for the feeding of cattle under the name of palm cake. This palm oil question seems to be a very important one in tropical agriculture now. It seems in Africa to be more important than rubber. We have the great enterprise initiated in the Belgian Congo by a Britisher, Sir William Lever. His company has obtained concessions for about 1,500,000 acres of natural palm forests in the centre of the Congo. These forests seem to be very good, from what he has told us. The quality and yield are fully up to the standards found in Dahomey and on the Niger Coast. The average yield, if I can remember it rightly, is about 40 lbs. per tree. What the company has done in the Congo is to cut away the very small trees, spacing the larger ones a distance of about 30 feet one from another. That leaves about forty trees per acre. As soon as the bush is cleared away the trees grow much more rapidly. Sir William Lever adopts quite a special way of managing his huge properties. He engages small farmers and sends them out, and each one is put down on 2,500 acres of ground in the palm forest. He has got so many natives to work, and the work consists of clearing the bush away, and, later, keeping the 2,500 acres in good condition. The farmer sees that the native gathers fruit. He receives so much per year, a house, a boy, and other things. There are about 200 of these farmers working in the Congo, and there are still many more to go. It takes much time in the centre of Africa to put the industry on a good footing. For instance, Sir William Lever and his people must survey the whole of these 1,500,000 acres by next year. The way they are doing it is to go up in balloons and take photographs of areas of, I believe, five miles at a time. That is the only way to survey the country. They are building five big factories and running railways through these palm forests. The forests are about 300 miles square. That is an enormous surface, and if this company is successful many other enterprises of the kind will be started. Palm oil is first used for making soap and then by reducing the amount of fatty acids, the oil can be used for making margarine. I have heard an important man in the latter business say that there is a great use for palm oil in connection with his industry.

Mr. BAXENDALE: With regard to the thinning out of the trees,—if they are spaced thirty feet by thirty, that will give 48 trees to the acre. I should like to have rather more than that number with my rubber trees.

Mr. LEPLAE: All the plantations are cutting out trees.

Mr. BAXENDALE: Mr. Wickham and I argue this matter every day of the week, but we are not yet any nearer agreement.

Mr. EWART BARBARY: The people who are planting in Sumatra say the distance between the oil palms should be between 24 and 27 feet. Does the last speaker know whether in connection with the industry he has mentioned they are expressing the palm oil or getting it by solvents?

Mr. LEPLAE: You can extract the oil by solvents, but then you get oil that is not edible. The best oil is obtained by not warming the kernels. It is good for technical purposes, and the difference in price is very large.

Professor PERROT: Does Mr. Leplae know in Africa any firm treating the palm oil fruit by means of a solvent?

Mr. LEPLAE: No, I do not know of any. The oil would not be comestible.

A
Vote of Thanks
to
Dr. Torrey.

At the conclusion of the discussions, Mr. JOHN McEWAN, who was acting as chairman, took the opportunity of saying a few words in appreciation of the services of Dr. Torrey as Chairman of the Congress.

The Congress is now practically at an end, and I think we should record the sense of obligation under which those who have attended the meetings are to Dr. Torrey. (Applause.) For the information of those who have come in recently, I might explain I was only casually in the chair for one paper (Mr. Baxendale's); but Dr. Torrey has borne the heat and burden—the very great heat on some days—and has presided over the Congress most ably. I wish to tender him in the name of the Delegates their very best thanks. (Applause.)

Dr. TORREY: I am surprised and naturally very grateful for what you have said. Perhaps I can convey my own state of mind by saying what came uppermost at the moment, that it had not occurred to me that there was anything to be thankful for. I have very thoroughly enjoyed what I have done, and consider myself indebted to the Congress. The balance of the account stands on that side. At this Congress, I have had an opportunity such as a man seldom has given to him, of learning things that one has very much need to learn. On my part, I desire to thank the members of the Congress for the way in which they have attended it day after day, for the way in which they have listened to the papers, and for the activity and persistency with which the papers have been discussed, in such a way that there has not been a dull moment from first to last. (Applause.)

Part II.

CHAPTER I.

International
RUBBER
CONGRESS,
NEW YORK
(City).

CONTENTS.

The following is a list of the principal Papers read at the RUBBER CONGRESS held in NEW YORK CITY, September to October, 1912.

PAGES.

The Plantation Rubber Industry. By CYRIL BAXENDALE .. .. 369 to 377

The Present and Future of the Native "Hevea" Rubber Industry. By JACQUES HUBER, Ph.D., Director of the Museu Goeldi, Para, Brazil .. .. 377 ,, 384

Notes on the Acclimatization and Cultivation of the Guayule (Parthenium Argentatum Gray). By FRANCES E. LLOYD .. .. 384 ,, 389

Tapping of Rubber Trees. By R. FYFFE .. .. 389 ,, 390

Farming by Dynamite. By HAROLD HAMEL SMITH .. .. .. 390 ,, 395

Possible Rubber Producers in the Temperate Zone. By CHARLES P. FOX .. .. 395 ,, 398

Commercial Possibilities of Synthetic Rubber. By LOTHAR E. WEBER, Ph.D... .. .. 398 ,, 401

Problems in Vacuum Drying. By J. P. DEVINE .. .. 401 ,, 407

Lithopone and Oxide of Zinc in the Rubber Industry. By. G. C. STONE and GILBERT RIGG, New Jersey Zinc Co. .. .. 408 ,, 411

A new rule of Vulcanisation. By A. O. BOURN, Providence, R.I. .. 411 ,, 416

Notes on Tension Tests of Rubber. By P. L. WORMELEY, United States Bureau of Standards .. .. 416 ,, 421

Laboratory Organization in the Rubber Industry. By FREDERIC DANNERTH, Consulting Industries Chemist.. .. .. .. 421 ,, 429

Railroad Air Brake Hose. By J. S. SHEAPE, Engineer of Tests, Illinois Central Railroad .. .. 429 ,, 431

Navy Specifications. By E. S. LAND, Naval Constructor, United States Navy .. .. 432 ,, 434

Some Observations on the testing of steam and air-brake hose used on railway locomotives and cars. By G. C. BISHOP, Supt. Motive Power, Long Island Railroad Co. .. .. 434 ,, 440

A brief history of fire hose Specifications in the United States. By E. A. BARRIER, Factory Mutuals Laboratory .. .. .. 440 ,, 445

Contracts. By Arthur W. Stedman .. .. 446 ,, 449

Report of the Rubber Committee of the American Society for Testing Materials; Standard Specifications for Rubber Products. By E. B. TILT, Chairman of the Committee .. .. 450 ,, 452

Report of the Rubber Section of the American Chemical Society. By D. A. CUTLER, Chairman of the Section .. .. 452 ,, 453

The Plantation Rubber Industry.

By

CYRIL E. S. BAXENDALE.

It is remarkable that—as civilization has become dependent on cultivated produce—the profitable cultivation of rubber should have been, for years, open to doubt.

It was in 1876 (not less than 36 years ago) that *Hevea* seeds were brought from Brazil to Europe by that prince of smugglers, Mr. H. A. Wickham. There was an earlier attempt, but as the few seedlings raised all died, we need not waste time over that. From the 70,000 seeds collected in Brazil by Mr. Wickham, 2,800 plants were raised at Kew Gardens (London) and, in the same year, shipped to the Perideniya Gardens of Ceylon (Ridley tells us) as a depot for the plants from which the cultivation might be spread all over those British Colonies wherein the plant could thrive.

In 1877 a case of 22 plants reached Singapore and were successfully planted by Mr. Murton, the then curator of the newly-founded Botanic Gardens there. The same year the first *Hevea* trees arrived in the Malay States. Two cases were sent from Ceylon to the late Sir Hugh Low (British resident of Perak), who planted them at Kwala Kangsar, and, I am glad to say, he lived long enough to see something of the great success of the industry that he helped to found.

It may seem strange that these trees reached maturity many years before it was realized that they were capable of yielding a sufficient quantity of rubber to make their regular tapping profitable. The only explanation I can offer for this is that the duty of tapping them was relegated to Sakeis (Malayan Aboriginals), who adopted the same methods they applied to the collection of wild rubber ; that is to say, they hacked them with choppers, while the results they achieved were insufficient to tempt any capitalist to put ten cents into the business.

It is to our scientist friends that we owe the primary knowledge of how these trees might be made profitable. On what we now consider to have been a red-letter day in the year 1888, Mr. H. N. Ridley was appointed director of the Botanic Gardens in Singapore, and very soon afterwards commenced experimental tapping ; but it was not until 1891 that the first sample of plantation Pará was sent to London from Malaya, and was favorably reported upon by experts. During the nineties, several gentlemen in Ceylon, and Mr. Derry and my learned colleague, Mr. Leonard Wray, in Malaya, continued the experiments.

The first actual sale recorded from Malaya was in 1899, from the trees planted by Sir Hugh Low, and realized 3s. 10d. a pound. The trees were then 22 years old. To the brothers Kindersley belongs the honor of first planting rubber on a commercial scale in our country. That was in 1895, and within three years the late Mr. W. W. Bailey and several other planters, including the humble individual now addressing you, had summoned up sufficient courage to plant a few hundred acres amongst them. To attribute this slow development to lack of enterprise would be unjust. If any explanation is required it must be attributed to lack of money. At the time of which I am speaking, we were all coffee or sugar planters, struggling for a bare, very bare, existence. Some of us may have had the privilege of being on terms of a nodding acquaintance with men of means, but not many of these could recollect that rubber was useful for any practical purpose, except for the erasure of pencil marks.

A favored few had seen or heard of a Mr. Charles Rolls, traveling in a horseless carriage preceded by an ancient man on foot, carrying a red flag as a danger signal; but, probably, none of these realized that this object of merriment was the forerunner of the greatest mechanical industry of the age, or if they did, would not, at any rate, have found it a reason for supporting the schemes of would-be rubber planters.

Rumors of remarkable results from the first planted *Hevea* trees of Ceylon and Malaya reached Europe, and as the years rolled on a few speculative—or may I call them far-sighted—persons staked a portion of their savings on the new venture.

The extension of the area under *Hevea* in Malaya, which in 1905 amounted to about 38,000 acres, increased at an average rate from that year of about 70,000 acres per annum. The total area at the end of last year (1911) was 542,877 acres.

During 1909 the income from the older companies attracted the attention of the investing and speculating public of Europe in general —and Britain in particular—as being unusually large for an agricultural industry. At the same time the value of crude rubber went up by leaps and bounds, bewildering even to those acquainted with the elastic nature of the subject; and indiscriminate speculation was indulged in, of which the promoter of many a wild-cat proposition took full advantage.

It is said that the boom far exceeded that which heralded railway development 70 years ago, and can only be compared with another that occurred in the reign of our late Queen Anne in connection with a venture known as the South Sea Bubble.

Well, *our* Bubble has since deflated somewhat, I am glad to say, but it has not burst; and I think it may be said that the planters who had borne the burden and heat of the day generally kept their heads in spite of the somewhat embarrassing attention paid to their humble efforts, and this had much to do with steadying the market when the bubble was soaring, and also in stopping total deflation when investors rushed to the other extreme.

The reason the Malay Peninsula attracted most attention for this purpose was, primarily, its regular rainfall. It is commonly said that there are two seasons in that country. One is the wet, and the other is the d——d wet season.

This peculiarity is due to its unique situation as the meeting place of the N.E. Monsoon of the China Sea and the S.W. Monsoon of the Indian Ocean. After the subsiding of the rains of the S.W. Monsoon, the N.E. commences, and as the width of the Malay Peninsula does not exceed 170 miles in any part, the land on both coasts is affected by either monsoon.

I have kept the rainfall records at Jugra for 14 years and have never experienced a month without rain, and rarely a month below the average rainfall of Britain. It must be admitted that some of us, in cabling particulars of our monthly outputs, explain a shortage against the estimate by adding " owing to the drought " ; but the truth is we have yet to experience the true meaning of the word " drought." There are very few days in the year when it is too wet to work, and this, of course, gives us a great advantage over the collector of wild rubber on the Amazon, where I understand there can be no tapping for several months of the year.

A very considerable change has come over the conditions of life in Malaya. I regret to say that many of the plantations can hardly yet be described as health resorts ; but there has been an immense improvement, and in view of the more or less recent discoveries of our medical men there is good reason to hope that the improvement will continue. To Sir Patrick Manson and Professor Ross we owe the original discovery that the *Anopheles* mosquito is the principal, if not the only, carrier of malarial infection, and the doctors of Malaya have amongst them done excellent work as a result of this discovery. I would single out Dr. Malcolm Watson for special mention, as his work as medical adviser to plantations has come, particularly, under my notice.

He has discovered that the variety of *Anopheles* which favors the coast districts, rarely, if ever, travels more than one-half a mile from the jungle, and there is practical immunity in dwelling-places at this distance.

The valleys, in some of the inland districts, harbor another variety of the *Anopheles*, the spawn of which can exist in running water, and can only be got rid of by carrying the water away in enclosed drains. Interesting experiments in this direction are now being carried out by several rubber companies in Selangor.

Thanks to the natural richness of the soil, a considerable amount of capital was attracted to British Malaya from Ceylon, where there was comparatively little suitable land available, and our community owes something of its success to the cash and experience introduced from that colony.

Although the new applications for land are still sufficient to tax severely the resources of our over-worked (and not over-paid) Survey Department, the increased rent and export duty has driven a certain amount of British capital to the Dutch Colonies of Java and Sumatra, and considerable development has recently been made in those islands, as well as in Borneo.

When stating these facts, I do not wish it to be understood that I am advocating the avoidance of British Malaya as a country for investment, or that I would belittle the fine work accomplished by my fellow countrymen who have been officially responsible for the development of that region.

On this occasion I have the honor to represent the Planters' Association of Malaya, who amongst them manage a total of upwards of 600 plantations, with an invested capital of about fifty million pounds sterling, a value which through their efforts has appreciated to several times that amount. I am quite certain that I should not be correctly voicing that community if I conveyed the impression that we would prefer any form of government than that approved by our Sovereign Lord, King George.

The success of our industry is largely due to the confidence inspired by the existence of an absolutely honest and conscientious public service. Mistakes have been made, but these have been due, entirely, to the excessive zeal of those in authority, who desire that the whole country should participate in the prosperity of our industry; and judging by past experience in times of adversity, we may reasonably expect that if our burdens become too grievous to be borne, we shall obtain the relief necessary to meet the stress of competition.

With your permission I will now direct your attention to a few details connected with our plantation work.

At first, the cultivation was almost entirely confined to interplanting *Hevea* trees through the old fields of coffee, but a few bold spirits ventured to clear the jungle for this product only. But it is regrettable to mention that some tempered their rashness by planting rubber and cocoanuts in alternate lines, and had to pay rather heavily for their caution, by being forced to cut out either one or the other when both required more room for expansion. I need hardly mention that it was usually the cocoanuts that were condemned. As one who does not believe in keeping two good things in a parcel not large enough to hold both, I have planted the two products in adjoining fields; and, perhaps, for that reason, my feelings have always been harrowed by the woeful spectacle afforded by the destruction of thousands of these valuable palms.

The interplanting of *Ficus Elastica*—the red rubber of commerce (this has no connection with the rubber shipped from the Congo)—was at one time popular, particularly on the estates of the coast districts; but although this variety yielded a fair quantity at the first tapping, it did not compare at all favorably with *Hevea* in continuous yield, and the tapping seemed to check its growth. A considerable area remains under this variety in Sumatra, but it has become a negligible quantity in the Peninsula, and has never been in favor in Ceylon.

At the outset we obtained our *Hevea* seeds from the original stock, and this was an expensive item, which has gradually declined in cost, now that we have trees of all ages and have no certain knowledge of any difference in the quality of the plants, whether raised from seeds of old or young trees.

In the hilly districts ordinary surface drainage is required, but near the coast great care has to be taken to select land which can be drained efficiently, and this work frequently involves considerable expense. Fortunately for us, Malaya is not subject to tidal waves, as large areas of our finest plantations are only a few feet above sea level. The drains are laid out with the compass, and cut through the living jungle before felling. The jungle is then cut down and the branches lopped to a level of about 4 feet from the ground. A few weeks later the burning is carried out by a line of men walking at ten to twenty yards apart, with their backs to the wind; and in favorable weather the undergrowth and smaller branches are consumed. Afterwards the unburnt branches and small trees are piled and burnt, and generally speaking, when this is done the field is described as cleared, although the stumps and trunks of the big jungle trees still remain on the land. Recently on some estates heavy expense has been incurred in getting rid of these, before planting, as a precaution against the spread of root disease and white ants. It is a debated point as to whether the risk of loss by disease justifies such expensive precautionary measures, and whether it is not better to wait for three or four years, when the few rotten logs that remain can easily be got rid of.

Planting is done either from stumps or seed at stake. In the former case, the plants are taken from the nursery, being then from 6 months to 2 years or even older, cut to a length of 3 to 4 feet, the roots hacked back and then planted in the holes previously prepared for them. It says much for the vitality of the *Hevea* that it usually survives this drastic treatment and starts to sprout afresh, within a month, if the weather is propitious. From this time on ensues a battle between the planter and the original jungle, which endeavors to regain possession of the land. Numerous kinds of obnoxious weeds—coming from Heaven knows where—also make their appearance.

From time to time there crops up something almost as bad as weeds. I refer to the wearisome controversy as to whether it is not desirable to allow grass to grow or to cultivate some cover plant which will extinguish the weeds. There are one or two cover plants which do not cause any permanent damage and have even proved beneficial on some plantations, when they have lacked sufficient cash to maintain a proper upkeep and when the only alternative was abandonment. I have experimented with small areas under grass, but the results have not shaken my belief in clean weeding, to be followed by digging or ploughing whenever there is a sufficiency of funds and labor. With a sufficient supply of these sinews of war, the planter can hold his own, and after three or four years, aided by the shade then afforded by his trees, he becomes master of the situation.

The longed-for harvest then occupies his attention ; and nowadays his thoughts turn, naturally enough, to the curing factory. When I started tapping, the word factory had not been invented, or, at any rate, used in this connection. I began by settling the latex in my washing basin, rolling the rubber with a beer bottle (an empty one) and drying it on the veranda. Then acting under strong domestic pressure, I moved the scene of operations to the stables, and carried it on there until there was no room for the horse. Next I built a little shed and bought a hand mangle. The next move was to the factory of to-day.

You will, I think, be interested to hear something about the cost of production. We planters are frequently twitted about our old promises of cheap production, and these are compared with actual costs, which in some cases exceed 60 cents (U. S. A. currency) a pound. The twitting, curiously enough, was most severe when rubber was worth from two to three dollars, at which time we had to pay an ad valorem export duty and charges, based on these extremely high prices. Then, as there were not quite enough experienced planters to go round, assistants, as well as managers, thought they would like to participate in the general prosperity, and expected either larger salaries or else commissions. Our coolies also felt that what was good for master must be good for man, and demanded either more pay or less work—generally both. Even the government suffered from the prevailing spirit, and on new applications increased the rent and charged a premium on the land. Shareholders often seem to forget to study the other side of the profit and loss account and to compare the price actually obtained against the price we figured on when estimating the cost of production. Moreover, we did not contemplate tapping our trees at four years old, at which age the rubber is naturally more expensive to collect.

I admit that I speak with prejudice, but it seems to me only right and proper that those responsible for supervision should enjoy some of the fruits of the industry, when the industry can well afford it. There are many other items of expenditure which will automatically decline when the value falls.

I do not desire to encourage the expectation that the yields from our closely planted trees will approach that obtained from those first planted. The latter were usually planted at wide distances, and enjoy as much light and air as the heart of a tree can desire. Ten years ago, I collected 18 lbs. of rubber in 35 days from one of the trees planted by Sir Hugh Low; while from avenue trees of my own planting, 14 years old and 7 feet in girth, results have been obtained far in excess of those planted in the fields. It is for this reason that I am inclined to deplore references in published reports to yields *per tree*. All calculations should be based upon the yield per acre. Probably the average number of trees planted to the acre in Malaya is nearer 200 than 100, and thinning out is inevitable as the trees expand. Thus, your trees are an uncertain quantity, whereas the acre is always the same.

A well-known botanist who studied the *Hevea* in its native land used to urge us strongly to plant at 40 x 40 feet, *i.e.*, 27 trees to the acre.

The *Hevea*, like most quick growing trees, is extremely brittle; and, at this distance,would suffer severely from the wind, but if I allowed, for the sake of argument, that every tree reached maturity, I found by comparing the results from avenue trees against the results from closely planted fields that up to 8 years old I should have harvested less than half the quantity of rubber from the same area had I adopted our botanical friend's advice.

It is true that I should have economised to a certain extent on the actual cost of collection, but not sufficiently to compensate for the loss of rubber.

Thinning out as the trees get older and require more space, has been opposed on the ground that the dead roots encourage the spread of disease. I have pursued this policy for several years past and cannot find that the fear is justified. Indeed. as the years roll on, I become less anxious about plant diseases and pests of all kinds. *Fomes Semitostus* (our worst fungus disease) and white ants (the most destructive of our insect pests) have lost their terrors for me now that I know how to keep them in check; and as the loss from all causes on the plantations I am connected with does not average two per cent. after attaining maturity, I cannot, justly, be charged with "turning the blind eye" in that direction.

The most plausible argument against the future output of plantations is that of shortage of labor. It is true that most plantations are at times short of labor, but I think this must generally be attributed to the manager's desire to keep down expenses. Out of a total of 227,985 coolies employed on Malayan plantations 126,665, or rather more than half, were imported from India. The average period of service on the plantation does not exceed two years—although many of these return after a holiday in their native land; and the difficulty is to engage during the recruiting season the exact number that are required to make good the probable departures during the rest of the year, without becoming burdened at the beginning with labor for which there is no profitable employment.

Within two years the plantation labor force has more than doubled. I do not believe that by increasing the rate of wages any great stimulus would be given to Indian emigration. Tamil coolies are more easily recruited for some plantations at half the wages paid on others which are unpopular, owing to unhealthiness or to some other cause; and this fact is becoming more clearly marked, since those employed at the lowest rates have found themselves able to remit more than half their earnings to India, and their savings in three or four years are sufficient to establish them as capitalists when they return to their native villages.

The future success of estates which are unpopular with Indians will depend on the attractions they can offer to Chinese or Japanese. To these the rate of wages is of more importance than any other consideration; and there is practically no limit to the number that can be recruited—at a price.

It must be remembered that by doubling the cost of labor we do not double the cost of production. Generally speaking, the average cost of tapping is less than one-half the total cost of production, if we include home charges; and as the majority of the trees now being tapped have barely reached half their full yielding capacity, labor rates can, if necessary, be materially increased without raising the cost of production, when the trees attain maturity.

Recently some consideration has been given to the question of manures. From Ceylon some interesting results have been reported, but in Malaya little has been done in this direction, except on some estates where the soil is excessively rich in humus, and lime has been applied to correct the acidity, with good results.

My own opinion is that for some years to come, at any rate, systematic cultivation of the soil will be of more value than any manure, but the experiments in Ceylon are deserving of attention; and the Agricultural Department of Malaya, if they have not already done so, might study the question with advantage.

It has been suggested to me that you will be interested in an estimate of the supplies that are to be obtained from plantation sources, and it is obvious that a paper of this kind would be incomplete without it. It is not easy to obtain reliable statistics of the cultivation in all the tropical countries in which rubber is grown. Naturally, the yields vary considerably, and the high price has undoubtedly encouraged more vigorous tapping on many plantations than would have been considered advisable if the price had been less tempting. I know fields where from 800 to 900 pounds an acre have been collected for two or three successive years, but I question if such high yields can be maintained. A first-class, well-managed plantation may be expected to yield an average of 500 to 600 pounds an acre for as many years as our experience guides us, but we must assume a considerably lower average from all plantations. The area under rubber in the Malay Peninsula at the end of 1911 amounted to 542,877 acres, and as far as I can ascertain the total area under this cultivation in the world amounts to about 1,000,000 acres. We know that during the half-year ending June 30, 1912, the exports from Malaya amounted to 9,038 tons, and from Ceylon to 2,252 tons. Allowing for the output from India, Sumatra, Java, etc., I estimate the total output of plantation rubber will be from 25,000 to 30,000 tons for the whole year. The annual increase will be fairly steady, and at about six years from date the production is likely to amount to 100,000 tons per annum or, in other words, equal the total consumption of rubber during the year ending June 30 last.

During the year ending June 30 (1912), with rubber averaging 5s. 2d. (say a dollar and a quarter) a pound, consumption—according to the figures recently published by Messrs. Hecht—increased by 25,482 tons. I am aware that this statement has been challenged by other authorities. We are told that they are *eminent* authorities, but as they, unfortunately, published their views anonymously, we are obliged to take their word for it.

The most pessimistic of these that I have read calculates the increase at about 14,000 tons, and if we accept this figure in preference to Messrs. Hechts' (I don't know why we should), and assume that this increase will be maintained, the requirements six years hence will amount to 184,000 tons, so that the struggle between plantation and wild rubber does not appear to be very imminent.

I have now told you as well as I can what I believe to be the immediate course of events. To you gentlemen, who are manufacturers, I would say this, whether our achievements will lead to prosperity for *our* industry will depend entirely on the growth of *your* industry. Speaking personally of my first few years' experience in tropical agriculture, I was engaged in planting coffee. At the outset of my career in this line, the price in local currency and weights was $40 a picul, and I saw it fall to $16. This experience is put in the shade by that of my brother planters who were interested in pepper and cinchona. Our misfortunes were due to the fact that an increased supply did not lead to any considerable increase in the demand for these products. We have yet to hear of anyone who shakes the pepper castor more vigorously over his potatoes owing to a slump in the price of pepper, or increases his dose of quinine because the quantity of chinchona offered at the auction sale is in excess of anticipations.

The future of the rubber industry depends on whether the planter can confidently anticipate manufacturers digesting the increased supplies.

A well-managed, favorably situated, mature plantation can produce with a handsome profit at 2s. 6d. (60 cents) a pound. It must be remembered that the increased demand depends on the new uses to which it may be put, the increased demand for uses to which it has hitherto been put, and the supply demanded by making good the losses by wear.

As an illustration of what I mean, I will take the case of solid and cushion tires, which, if not now, will perhaps shortly absorb more rubber than is used for any other purpose. If we assume that 1,000,000 of these tires are used through the world this year, and only the same number next year, the amount of rubber required on this account will, other things being equal, be only that amount necessary to replace the loss involved by wear and tear.

The irregularity of the cost has undoubtedly militated against its use in some directions. For instance, I am informed that whereas electric light mains and leads were in the past invariably insulated with rubber, paper insulation has been substituted in many cases. Experts tell me that rubber is preferable for this purpose, and no doubt a number of instances will occur to you gentlemen, where it would be preferable if the price admitted of this use.

This brings me to the crucial question from the planter's point of view, and a question which my present audience is in a better position to make an authoritative reply to than any audience previously addressed by a planter.

We can guarantee an enormously increased supply of rubber and will in future years be content with a much lower price than now prevails. What we want to know is whether there is to be a glut in the market, and a scramble to sell, with every successive increase in the supply. Perhaps, gentlemen, you can allay the misgivings of those planters with the weaker faith in the future of the industry, and can send them, through me, assurances which will encourage them to hope for a continuance, even if in a modified degree, of the prosperity we have recently enjoyed—a prosperity which, I believe, has never been rivalled by any agricultural industry in all the history of the world.

[NOTE:—At the date this paper was read, rubber was between five and six shillings per lb.—EDS.]

The Present and Future of the Native "Hevea" Rubber Industry.

BY

JACQUES HUBER, PH.D.,

Director of the Museu Goeldi, Pará.

The opinion is common among persons interested in plantation companies, that native Brazilian rubber will be entirely knocked out by the product of the eastern plantations within the next ten years, when the output of these will be over 100,000 tons.

Regarding those opinions, it is evident that "the wish is father of the thought." Most of these prophets hope that the disappearing of the Brazilian crop from the market will relieve the plantations from the danger of over-production. Others perhaps are instinctive enemies of Brazilian rubber because of the manner in which Brazil has protected its coffee output.

If we consider the problem from a higher and more objective point of view than that of the plantation shareholder, if for instance, we consider the views of the manufacturing industry, we find that there is no necessity for the disappearance or reduction of the Brazilian crop; on the contrary, there will be an increased need for the Amazonian grade, and especially for the Hard-Cure Pará rubber.

Of course, the wonderful development of the whole rubber industry would have been seriously checked had it not been for that very necessary asset. The plantations and their rapidly increasing production will enable the manufacturing industry to develop without fear of shortage. The opportunities for the manufacturing industry are increased by the low cost of the plantation rubber, which can be sold at much lower prices than those prevailing for Pará. There is, further, no doubt that in their downward movement, the prices of plantation rubber are bound to affect, to a greater or less extent, even the quotations for the highest grade of rubber—the upper Amazonian Hard-Cure, the prices of which (without the prodigious development of the plantations and the improvement of their product) would, of course, have steadily and considerably increased.

The Brazilian producing centres appreciate the changed position of the rubber market, and instead of trying in vain to force the prices to a higher level, they are now preparing themselves to improve the position of the article by lowering the cost of production. This, of course, involves some sacrifice, but as the life of a whole country depends on it, the sacrifice will be made without muttering.

It is now generally conceded in Brazil, that that country cannot monopolize the rubber production of the world, and that we have to reckon with the fact that within a few years the Eastern plantations may produce more good quality low-priced *Hevea* rubber than Brazil.

At the same time the people interested in rubber plantations will probably realize the fact that the Amazonian rubber, although at the present time more expensive to produce than the plantation grades, will hold its position, thanks to its superior qualities and thanks to the efforts which are being made to improve the conditions of the industry.

Perhaps the following statements will help to give an idea of the true position of wild rubber in comparison with its younger brother, the plantation rubber, and may contribute to strengthen the conviction above expressed, which, I believe, is shared by all who understand this very complicated problem.

Superior Quality of Amazonian Rubber.

In spite of all the drawbacks of the native rubber industry on the Amazon, there is, fortunately, one great advantage—the *superior quality of the Amazonian product.* This remark has reference only to smoked rubber, and more especially hard-cure smoked Pará, the superior elasticity and strength of which (over the other grades, and principally over the plantation rubber) has been proved by the daily experience of the manufacturers, and by many scientific experiments.

It is hoped that we will before long have a complete comparison of the Pará Hard-Cure with plantation *Hevea,* as carried out according to the program of the Rubber Testing Committee.

For the moment I think that it is not yet possible to give definite figures, but I wish to call your attention to some points which seem to me to be even of more importance than the usual figures about tensile strength. I refer to the behavior with regard to the exterior influences—light and temperature—which together determine more or less the "keeping quality." The stock of rubber held by the Pará Syndicate is one very instructive example of the good keeping qualities of the smoked Pará rubber. After two years of keeping in more or less overheated stores, this rubber has only improved in quality. There are other more striking cases of the resistance of smoked rubber, which have always astonished me, when I heard on the other side, of the precautions which are necessary to preserve the plantation rubber from being injured by light or heat. Smoked rubber balls can be left for months in the sun without being spoiled, and this happens for instance in Bolivian *seringaes.*

Perhaps the keeping qualities of the raw rubber are not as important as those of vulcanized rubber, but it is probable that the raw rubber which better resists the action of sunlight and high temperatures, will continue to resist these influences when vulcanized. That is only a suggestion which I desire to bring to the attention of this conference.

One of the principal arguments of those who predict the disappearance of native *Hevea* rubber from the market, is the difficulty of exploiting scattered forest trees in comparison with the very easy exploitation of modern plantations. There is in fact a big difference in favor of the plantations, but it is compensated to a certain extent by the size and age of the native trees. It is worth considering that, in the Amazonian rubber forests a worker not only collects, but prepares by the tiresome smoking process from three to five or even ten kilograms of rubber, instead of the one or two kilograms furnished by one tapper in the planting districts of the East. (One kilogram = 2·2 pounds.) The principal cause of this difference is of course the age of the trees. There is no doubt that full grown trees can be more economically tapped than young trees.

Of course the eastern planters have succeeded in making the best of their young trees and in obtaining from 4 to 6-year-old trees, crops never thought of in former years; but if they continue in the same way, many of them probably will never have old trees in full bearing.

Even the scattered location of the native trees has some advantages, as it guarantees a longer existence and protection against the spread of fungus diseases. It may, however, in many cases, be advantageous to augment the actual number of wild trees by interplanting.

Another argument of those who oppose native *Hevea* rubber is the exhaustion of some rubber districts on the Amazon. For *Castilloa*, this argument has of course some weight, as the trees are cut down for the extraction of latex. Even in this case, it must be remembered that only the biggest trees (more than 15 inches in diameter) are exploited, and after a number of years there are other full grown trees to take their place.

For the *Hevea* trees extinction cannot be thought of, as even the most roughly treated specimens resist rough treatment for many years, and there is always a free supply of young trees. It is true that in some districts, where the exploitation has continued since the middle of the last century—as for instance in the Cametá district—the full-grown trees are badly injured, so that their yield has been considerably reduced. As a rule the trees are allowed to rest if they show any sign of exhaustion. Owing to this precaution and to the scarcity of labor, perhaps only half of the known *estradas* are actually exploited.

LABOR.

This scarcity of labor has always been one of the drawbacks in the development of the Amazon region. Native free labor is available in agricultural districts about Belem (Pará) and along Bragança railroad, and on the lower Amazon (Santareus and Obidos); but it is not abundant, and is at least six times as expensive as the average coolie labor on the Eastern plantation. The labor force in the *seringaes* consists mainly of native inhabitants of the northern provinces of Brazil. They are not working for a fixed wage, and the special arrangements they have with the owner of the *seringal* give them apparently a much more considerable share of the profit on the rubber than they would realize as simple agricultural workmen. That is the reason why the *seringaes* have such a fascination for even the settled agricultural population, which is periodically drained of young men, when there is any rise in the price of rubber.

But the financial superiority of a rubber gatherer over an agricultural worker is often illusory, as the "patrao" takes back in exaggerated prices (for the articles of first necessity) the money he has paid the aborer. In all cases, however, the labor is expensive on the Amazon, and though it is much more efficient than the coolie labor, as regards the amount of value of rubber produced, this compensation is generally not sufficient to bring the cost of production to the same figure as in the Eastern plantations. Where communication is easy and the freight charges are low, the trees are generally more or less spoiled, and give less than the average ; and in the districts where the trees give good yields, the freight is far higher.

Sometimes irregularity of supply is charged against native rubber. This of course is not so much the fault of the wicked *seringueiros*, who are sometimes accused of retaining their product for speculative purposes. It is rather attributable to the conditions of navigation on the remotest affluents of the Amazon. Speculating is of course always done to a certain extent by *seringueiros*, *aviadores* and export firms ; and we have seen some attempts of this kind in late years, but the meteorologic and hydrographic conditions of the country are chiefly responsible for the irregularity of the supply.

It is not probable that the distribution of the working periods can be altered, as these depend entirely upon the weather conditions. For the regulation of the transportation of the rubber from the remotest districts, the Brazilian Federal Government has taken important steps, so that it is hoped that in the future the supplies can be better distributed over the whole year.

Those who predict the ruin of the Amazonian rubber industry point to the fact that in the last years the output of rubber from that region has been almost stationary, in spite of the generally favorable conditions of the market and the "corner" in 1910. This is generally attributed to the exhaustion of the yielding power of the rubber trees in the more accessible districts and to the difficulty of working the more remote districts. This of course is right to a certain extent, but there are many other reasons for the arrested development of the rubber industry on the Amazon.

In the first line, there is the deficient organization of the whole industry, especially its financial side, which is so bad as to make the careless distribution of money frequently possible.

Unfortunately only a small part of the money earned in rubber production has been applied in improvements in the *seringal*, and in the general conditions of the rubber districts. Had there been a sound policy in this respect, the Amazon would have made very much greater progress.

It is only in recent years that the Government and the leading men in the trade have awakened to the fact that without the introduction of a rational scheme of improvements and reforms in the rubber districts ; and without a thorough reform of the whole organization of the industry it will be impossible for the Amazonian trade to meet the competition of the Eastern plantations.

Considering the immense extent of the territory, the scarcity of population and the complexity of problems, the task of such a reorganization is a gigantic one, and it is certainly excusable, if in the proposed plans there are some points open to discussion.

Within the scope of this address it is not possible, of course, to cover the whole scheme of reforms planned by the Federal and the State Governments, but I shall ask your permission to present here some points, which seem to me of particular interest.

PROPOSED REFORMS.

As to the improvement of the means of communication there would be much to say. The first thing to do is to improve and cheapen river navigation, by which most of the actual producing centers are reached. Railroads are indispensable along the course of the rivers which are obstructed by rapids. How much an improvement in the means of communications is needed, is shown by the fact that the *seringueiros* of certain remote districts are sometimes exposed to actual starvation, because of the holding up of the steamers by bad conditions of navigability.

Better food supply will come with cheaper and quicker communication. There are always several agricultural centers, especially in the State of Pará, from which the food could be sent to the rubber producing centers.

In the scheme of reforms planned by the Federal Government the upper Rin Branco region, with its extensive *campos* for cattle breeding, is considered as the principal food-supply center for the rubber districts of the Upper Amazon. Food production within the limits of these districts will always be small, because of the attractions which the free life of the *seringueiros* always has for the other working classes.

Sanitation is of course closely connected with good food supply. *It is perhaps the most important problem in the Amazonian region.* The successful extinction of yellow fever in the State of Pará is a very important step in that direction, especially as it proves that the Brazilian Government has at its command good men to carry out the much more difficult problems of sanitation in the interior.

Of course, all these measures will augment the output of rubber, as the proportion of the sick will be reduced, and the working power of the healthy strengthened. Then again, the rubber districts will be more attractive to immigrants and will encourage the settlement of a permanent population. For the producing capacity of the country, these improvements are probably of more importance than any other, as they bear on a factor keenly appreciated in Amazonia—the human element.

That does not mean that there will not be other reforms regarding the conditions of work in the rubber forests.

First of all, I have always advocated the special protection of young *Hevea* trees in the rubber forests, and even interplanting in cases where this is possible. More than 10 trees per hectare (1 hectare = 2½ acres) are seldom met with in the natural rubber forests, and even if we do not intend to have a pure rubber plantation, it should be possible to obtain in favorable situations at least 20 trees per hectare by protecting the young trees and replacing only occasionally some of the other forest trees by *Hevea* trees.

I am sure that the methods of tapping used in the East could be applied to the old forest trees, thus increasing their yield, and the whole output of the rubber forest would be much larger, perhaps double the present amount.

There are, however, two principal reasons which have until now, prevented the introduction of these methods in native *seringaes*. First: most of the trees are already deformed by the old systems of tapping with the *machadinha*, so that it would be impossible to work them with the tapping knives without giving them first a rest of several years. Second: it would be difficult to train the *seringueiros* for systematic tapping according to the methods used in the East.

There are other reasons, for example, the moisture content of the bark in these forests, which would probably prevent the latex from flowing straight down to the cup. In spite of these circumstances, I thought it advisable to encourage some experiments of tapping forest trees, according to the best methods used in the East.

As is now generally admitted, the superiority of the Amazonian *Hevea* rubber is due principally to the smoking process. It would not therefore be prudent to introduce any other method of preparing the rubber, without having positive proofs of its superiority over the smoking process. In Europe it is known that a considerable part of the Amazonian *Hevea* rubber is produced in the form of scrap, and "Sernamby de Cameta!" Of course it would be better to produce this part also in high-grade quality, but that would not be possible even with the greatest care, as part of the latex always coagulates on the bark of the trees and on, or in, the collecting tins. The idea of turning out only one standard grade of Amazonian *Hevea* rubber is, therefore, not feasible. It is, of course, possible to work the scrap into crepe, as is usual in the Eastern plantations, but then we should always have two grades. If the Cerqueira Pinto process—proving superior to the smoking process—should be carried out more commonly, it would allow us to reduce the scrap considerably; and as it permits the coagulation of watery latex, it would avoid the loss of considerable quantities of latex, which in rainy weather are actually not worked out either in form of smoked rubber or in form of scrap; but simply thrown away.

PLANTATIONS ON THE AMAZON.

Is it possible to start plantations successfully on the Amazon? This is a very important question, not only for the inhabitants of that region, but also, I think, for the whole rubber industry. As I have always advocated plantations on the Amazon, I have naturally followed with great interest the planting movement in Brazil, which some years ago—owing to the news of the splendid success of the eastern plantations, and thanks to official protection—has set in with renewed energy.

Of older plantations there are only a few, at least in the State of Pará, and these have as a rule not been very successful. Some private plantations may have given better results, but we have no records as to their production. On the other hand the new plantations, started under the protective State Laws, are now too young to permit a prophecy as to their future.

After the enactment of the State laws providing many advantages to the rubber growers, there was a rush in obtaining these advantages, especially the premium in cash. The registration at the Agricultural Department has reached in two years over eight million *Hevea* trees, to be planted in the next four years. Of these, 340,000 were reported as planted at the end of 1911. Most of the registrants are private planters, but the bulk of the proposed planting will be done by companies, one of which, on the river *Mojn*, is operating with American capital.

Comparing our conditions with those prevailing in the East, our chief advantage is that of cheap land, against which must be entered the very serious disadvantages of expensive labor and high export duties. It is true that the new laws reduce the duty to a considerable extent for rubber produced on plantations. There are other advantages, which have more bearing on lowering the cost of the first establishment of the plantations than of their production later.

Taken as a whole, planting on a large scale, by companies with foreign capital, is not at all out of the question in the Amazon region. Since I visited the Eastern plantations, I am, however, inclined to think that to operate our plantations in exactly the same way, as, for instance, in Malaya, is neither possible nor would it be advisable. This is impossible with the Brazilian worker, who is at least three times more expensive, even taking into consideration his higher working power. He is much more independent than the Indian coolie and imported coolies are undesirable in most cases.

I think that by introducing contract work to a great extent, some big plantations could be established in places where frequent supervision as well as free supply of labor and food can be assured. The neighborhood of Belem or the lower course of the Amazon offers these conditions. Of course, there will be some danger of frequent changes in the labor force, but the best elements, if well treated and reasonably paid, will stay and form a nucleus of skilled workmen able to introduce the new comers into the work.

In a general way, however, I am of the opinion that the rubber planting on the Amazon has to be carried out either by the actual occupants of the country or by companies with very large funds, which can combine the planting with an efficient scheme of colonization.

In any case—and this cannot be sufficiently insisted upon—the first work of every planting company should always be the sanitation of the place and the creation of an attractive *milieu* for the workmen, either by giving them the opportunity of settling under favorable conditions, with their wives and children, or offering them good housing and good fresh food at a reasonable price, if they are to be employed only for a limited time.

I have always had a strong belief in the necessity and usefulness of rubber planting done by the native and settled population. If every owner of a small *seringal* would only plant a thousand rubber trees, there would be in ten years a very sensible increase of the output. It is true that planting in this line is now generally done in a very deficient manner, and it will require a serious campaign of agricultural education to improve the condition of these small plantations. Above all, these plantations should be operated upon good principles of selection. Then they should afford an opportunity for experiment and demonstration of the best tapping methods applicable to the proper *seringaes*. Finally, they should show the way to the best method of improving rubber forests by interplanting.

There is no doubt that the big plantations will have some influence upon the methods used in the native rubber forests, and the reverse is likewise true. It would seem strange that in the Amazon region, the very home of the *Hevea Brasiliensis*, its cultivation has not made more progress, in spite of the many efforts in that direction. The cause is not only in the general conditions of the country, and in the scarcity of labor, but perhaps principally in a factor which unfortunately has too often been overlooked—that of management. In the East the rubber plantations were nearly all started by men of experience in the management of tea, coffee or other big estates. In Amazonia there are practically no plantations on a large scale and trained plantation managers are seldom to be found there. They have, therefore, to be contracted for, from Southern Brazil or from the Eastern plantations. They should be familiar not only with rubber planting, but should be able to adapt themselves to changed conditions of life and work.

In conclusion, we must admit that the evolution of rubber planting on the Amazon will probably be something quite different from what was witnessed in the Eastern plantations. There is no doubt, that during the immediate future the East will continue to lead in planting enterprises. On the Amazon the plantations will be established more slowly, but they will be of great importance as the necessary complement of the native rubber extraction.

The old method will be helped and develop from a crude empirical process to a scientifically established and more economically operated industry.

[The Editors regret to announce that Dr. Huber died in February, 1914.]

Notes on the Acclimatization and Cultivation of the Guayule (Parthenium Argentatum Gray).

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Since the time when, as a result of the then probable prejudice to the natural supply of guayule shrub, the problem of its cultivation was attacked, the question as to: What changes in the responses of the plant might be expected on the increase of water supply—has been uppermost. An answer has been obtained as yet only in general terms, and, from the practical point of view of the guayule rubber manufacturer, it is less satisfactory than from that of the plant physiologist. Indeed, in searching for a complete answer, the time element is so great that a number of years is required for working out satisfactory data. Those available to the present writer have been obtained from plants grown for two seasons at Cedros, Zacatecas, Mexico; for three seasons at Tucson, Arizona, from material derived from Cedros, and from the Stockton plateau, Texas; from a single plant grown by Dr. H. H. York, at Austin, Texas, also from Stockton plateau material. At Auburn, Alabama, plants have been grown both in the open and in the glass-house, both from Cedros seed and from Texas stocks, for three years. Seedlings two years old, grown in Tucson, have also been available.

The information based upon the above material will be briefly presented in what follows. The situations indicated include the semi-arid Chihuahuan and Sonoran deserts—within the former of which the guayule has its natural habitat—the moister climate of Eastern Texas, and the relatively wet region of middle Eastern Alabama, which has a rainfall of 45 to 55 inches. Before contrasting the plants from these widely different places we may profitably compare those growing naturally within the proper area of distribution. It has already been shown* that the guayule is by no means uniform in structure within this area, the differences being such as may be referred to differences in the amount of available moisture, which may in turn be attributable either to greater rainfall or to the character of the soil, chiefly mechanical. The structural differences referred to are those of relative thickness of the "bark," or, more properly speaking, the cortex, these being such that, the greater the available water, the relatively thinner the cortex.

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* Publication 139, Carnegie Institution of Washington.

Correlated differences in the length of the annual accretions of stem are to be noted. The more rapidly grown stems display a greater tendency to obvious shrinkage of the cortex, so that, in place of the rounded surfaces of the slowly-grown stem, longitudinal corrugations are to be seen. I am creditably informed that such characters are displayed by the guayule from the easternmost region of its distribution area, in the State of Nuevo Leon, to an extent so marked that the practical extraction of crude rubber is reduced, roughly speaking, to about 4 to 5 per cent. on mill weight. This may not necessarily be taken to mean that the amount of rubber relative to the volume of the rubber-bearing tissues is less than elsewhere, but that the volume of woody tissues (wood, hard bast, etc.) is greater. Nevertheless, this may be the case, and I know of no studies which have been made to settle the point. But, in the light of what we do know about the relation of water supply to the amount of rubber secreted, it is not improbable that the actual intracellular secretion in these Nuevo Leon plants is somewhat less than in dryer regions.

The well-known habital differences between the so-called "*macho*" and "*embra*" guayule furnish another case in point. *Macho* guayule is sparingly branched, has thick "bark," and the younger branches shrink little on drying, and, at all events, do not show longitudinal wrinkles. *Embra*, on the other hand, is very much branched, the younger twigs become furrowed on drying, and the bark is relatively thin. In the former the flowering shoots are sharply delimited from the leafy shoots; in the latter, the *embra* guayule, they are not. Whether these two types represent racial differences or not I do not care to discuss here, but it is well known in Mexico that, from the practical point of view, the distinction is important, as *macho* guayule is considered distinctly better as regards rubber content. Since both types may be found associated in the same locality it seems improbable that the intracellular secretion is unequal in them, but that the inferiority of the *embra* is due to the greater relative volume of the woody cylinder, and the relatively greater number of smaller branches. It is significant that when guayule of any type is put under cultural conditions, and supplied with abundance of water, the habit of the plant swings away from the *macho* toward the *embra* type of growth, in that there is a tendency for the leafy shoots to run out into flower stalks, and toward the greater development of wood.

These tendencies are to be seen whether the plant is grown in the desert under irrigation or in regions of higher rainfall, and are a summation of differences in minor details which I have treated more fully elsewhere. Of these I need mention but one, and that, in general terms, to the effect that the greater the water supply, up to the limits thus far observed, the greater the rubber-barren, fibrous or woody tissues in volume and in hardness, the greater the irregularity of growth, and the larger the number of smaller twigs and of leaves. This condition is one which presents difficulties to the manufacturer of guayule rubber due to the greater relative volume of the bagasse, and this will obtain wherever the plant may be grown with an abundant water supply. In speaking of acclimatization, therefore, we may avoid, for the purpose of this paper, further description of the tissue development. It will suffice to confine attention to the rate of growth, tenure of life and the total amount and rate of rubber secretion.

TENURE OF LIFE.

When a plant is removed from its own to another habitat, the new combinations of environmental factors may prove fatal, whereas any one factor, taken in different combination, might not. So it comes about that the guayule can withstand a greater cold much more effectually under arid than under moist conditions. Of a lot of guayule plant grown outdoors at Auburn, Ala., both from seed and from stocks, in 1910, only one in 25 was living in 1912. In no case did death overtake them in the warmer periods, nor early in the winter, but rather late in winter during a cold snap following heavy precipitation. The evidence that the winter of Alabama offers untoward conditions is clear, however, before the plant is killed—it has a bad color, and a generally disheveled look, due to the numerous dead unshed leaves. The wet and cold weather conjoined constitute the limiting factor. This may be taken to mean saturated soil and a minimum temperature of 10 degs. Fahr., approximately that of the normal habitat. The part immediately affected appears to be the root, the cortex of which quickly disintegrates.

The tenure of life in a new habitat depends further upon the ability of the plant to resist new enemies. In Alabama, thrips and nematodes have been seen to affect the guayule badly. A strong tendency to form large and irregular lenticels on the lower portions of the plant in contact with the soil and nearby above its surface may be due to this proximity alone or to insect stimulation. The seed is poorly developed.

In the semi-arid desert, on the contrary, no case of death has been noted during three years, save as the result of insufficient irrigation. It is clear from this behavior that the resistance of an irrigated plant to drought is much less effective than that of one grown under the usual conditions. Though attacked by a fungous parasite, it has never been known to be seriously affected. The development of seed is abundant, and it has a vitality approximately equal to that of field plants.

RATE OF GROWTH.

When grown under irrigation in the semi-arid desert plants from transplanted stocks have attained in two seasons a maximum weight of 4.5 pounds, 3.5 pounds being a good-sized plant. These were a meter and over in diameter. The average weight for such plants would probably be 2 pounds. The dry weight of such plants, by which the rubber content must be calculated, is about 30 per cent. of the fresh weight. Allowing, therefore, a dry weight per plant of one pound, a not too conservative estimate, and assuming 10,000 plants to the acre, a 2 per cent. rubber content would yield 200 pounds of rubber in two growth seasons, followed by, say, six months of suppressed irrigation. At 60 cents per pound we have a return of $120 per acre for two years, or $60 per acre per year, against which should be charged, in addition to the usual costs, that of obtaining plants from seed for planting the ground. There is no evidence forthcoming that the percentage of rubber is greater, under the above-described conditions, than about 2 to 4 per cent. Assuming it, however, to be 6 to 7 per cent., guayule would even then scarcely be able to compete with onions in irrigated land.

The assumption is made that it would not pay to grow the plants longer than two years. In what follows under the head of rate of rubber secretion the reason for this will be seen in part. As to the rate of growth merely it may be said that the rate of increase of weight will be found to drop off rapidly after the second season's growth, to which must be added the fact that the smaller and therefore younger twigs contribute little to the accumulation of rubber. The rapid production of cork characteristic of the irrigated plant, results, it is probable, in the destruction of rubber. I find that the rubber in the cells which are active in giving off the innermost and therefore younger cork cells becomes broken up into small globules, and these disappear before the cork cell in which they are found gets very old. The cork as a whole appears, as a result, to be devoid of rubber, although in point of fact minute quantities are present in the cells referred to. It is practically impossible to measure this loss directly, but it may very well offset the further gain by growth quite materially. The death of various twigs and branches due to competition *inter se* must also contribute to loss of rubber. These circumstances, coupled with the reduction of the growth rate after the second season, indicate the economic maximum to have been reached.

In the moister climate of Auburn, Alabama, one suitable, as everyone knows, to the development of cotton, the rate of growth is less rapid than in the desert under irrigation. In the first season, a height of 8 to 10 inches is attained, but in the second season the additional growth is meagre. This fact, coupled with the uncertain tenure of life during the winter, would force the issue of considering the rubber secretion of the first season alone. This, as we shall see, is practically nil. It must be concluded that the possibility of growing guayule in this region is excluded by its abnormal development and slow growth, quite aside from other considerations. I do not raise the question of the character of the soil and its possible causal relation to the manner of growth, beyond saying that it is not related, it would seem, to the lime content, since the plant grown in the limestone soil of Austin, Texas, behaved in a very similar manner.

RATE AND CHARACTER OF RUBBER SECRETION.

Normal field plants. In the study of the rate and character of rubber secretion in experimental plants, the field plant has always been taken as a standard. The method, that of microscopic observation, does not enable one to state the results in terms of percentage relative to the total weight of the plant. Only chemical methods can be used for this purpose. Nevertheless much useful information can be gained by means of the microscope, particularly in regard to the method of secretion and the amount of rubber within the cells which secrete it.

METHOD OF SECRETION.

The first evidence of secretion is seen in the occurrence of very minute granules in the protoplasm. With the increase in their number and size they migrate into the sap-vacuole, and can be seen there by their Brownian movements. The analogy of this condition with that in the latex vessels of latex rubber plants is obvious, and indeed there may be more than mere analogy. In the definitive condition the rubber takes the form of a large droplet, almost filling the sap-vacuole, and rendered heterogeneous in its internal structure by the inclusion of encystments of solutions containing, probably, albuminous, carbohydrate and hydrocarbon substances. It is important to note here that the rupture of the wall separating two adjoining cells would be followed by the contact and merging of the two contained rubber droplets. This is the more sure result, the larger the droplets, and this explains the ready agglomeration of guayule rubber into " worm rubber " in the pebble mill when field plants rich in rubber are used. Conversely, the smaller the droplets, the more increasingly difficult is the same result, calling for special methods of treatment. The droplets can be so small as to be impossible of mechanical extraction in the usual sense ; this happens when they are so small as to form a suspension. The agglomeration of the suspensoids might be possible by the use of a minimum of water and the action of a " coagulating " agent, involving technical difficulties, the overcoming of which would be of the highest interest, but probably not economically of importance in this special case.

The largest rubber content under irrigation with known conditions was attained by plants of two season's growth in Zacatecas. At the close of the second season's growth the rubber content appeared as in the first stage of development, namely, as minute droplets or granules. Seven months later, after practically continuous drought, the amount of rubber in the cell was less than the maximum, but not by more than, say, one-fifth. It occurred as a continuous mass, almost identical in appearance with the normal. In this case, the small percentage of rubber, on dry weight, is due in very large part to the great development of tissues which do not contain rubber in appreciable quantities. The use of abundant water in irrigation cannot be said to have inhibited the secretion of rubber, but rather to have increased the growth of barren tissues.

The problem from the economic viewpoint is, therefore, in such case not the possibility of extraction so much as the increased cost of handling a much greater volume of bagasse, though it is probable that this in itself would lend some hindrance to extraction.

The material grown at Tucson from stocks showed its rubber cells to contain a dense emulsion-like mass, filling the sap cavity in August of the third season's growth. In the previous August the same cells showed only minute granules. Seedlings in August of their second seasons contained in each cell an irregular solid mass of rubber occupying one-tenth to one-eighth of the sap-cavity, accompanied by quite small droplets elsewhere. As the irrigation had not been controlled or definitely applied and suspended, it is probable that the conditions had not been the best possible for the secretion of rubber.

Practically the same result was obtained for plants grown from stocks at Auburn when examined early in September (1912) in their third season. If we compare these cases from Alabama and from Arizona with the mariola (*Parthenium incanum*) we find but little difference between them, either as regards the amount of rubber in the cells or its character.

The conclusion is inevitable, I believe, that the determining factor in the cultivation of the guayule is : control of the water supply. In the presence of an abundance of water applied irregularly and at too frequent intervals, it will require more than three years for the maximum cell content of rubber to be attained. A quantum approaching the maximum is reached, on the other hand, if plants which have been well irrigated for two seasons are then subjected to drought conditions for six to eight months. That merely rate of growth is not correlated with the secretion of rubber is shown by the condition found in a plant grown from seed in a 12-inch pot in limestone soil for two years, and planted out for a season (summer of 1912) at Auburn. These plants were in some cases at a standstill for a year previous to planting out, and for various reasons grew but little in the open. In all the specimens examined, the rubber was in the form of a dense suspension, and had not formed a solid mass.

Tapping of Rubber Trees.

By

R. FYFFE.

I feel sure that all who are interested in the production of plantation rubber are fully aware of the great importance of the operation termed "Tapping," and as I have been keenly interested in this subject for some considerable time, I would like to emphasize the necessity that exists in my opinion for improving upon the methods generally practised at present.

This subject was not discussed at great length during the conference in connection with the International Rubber Exhibition held in London last year, and it appeared to me that everyone was reluctant to say much about this subject; probably this can be partly understood when one considers its great importance. Still, the opinions and experiences of many must be of value and would assist to bring us nearer perfection if given utterance to.

After the close of the above-mentioned Exhibition, I had the pleasure of touring through Ceylon, the Federated Malay States, and Java, studying the cultivation and preparation of rubber, and from my observations the opinion which I previously held regarding tapping was greatly strengthened. Since I carried out some small tapping experiments, I have advocated a combination of excision and incision, and judging from the condition of the trees seen in the East, I certainly consider that the method of deep excision generally practised is drastic and is not conducive to the welfare of the trees.

The average coolie can scarcely be expected to tap by excision for any length of time without injuring the trees more or less, as if the maximum flow is to be obtained he must tap deeply, and as many of the laciciferous tubes lie very close to the cambium, he in his endeavour to get a good flow of latex exposes this vital tissue and often removes portions of it on the parings, and this results in a bad wound, which heals slowly and forms an irregular surface as well as gives access to fungus.

Apart from the above, the functions of the tissue which is being continually excised are interfered with and the development of trees must be retarded, and further excision is in many instances wasteful in that a very thick paring is removed, and I have seen parings about a quarter of an inch thick excised. This may be due from slack management, but from my observations I do not think that the average coolie puts more than 12 to 15 cuts to an inch of bark. This rapid and deep excision is an enormous drain on the resources of the trees.

I do not consider that incision only would be of any practical value, but I do consider that shallow excision and incision with a fine push pricker is superior to excision only. By shallow excision the bark is conserved, and by using a fine push pricker little disturbance arises from the severance of food-conducting channel, which must be of much value, as the development of the trees is unappreciably retarded and the renewed bark can be tapped much earlier. With a sharp push pricker, little injury is done to the cambium if the points do penetrate that layer, and as this vital tissue would never be exposed if shallow excision and incision was practised, a smoother tapping surface would result.

Although I am in favour of excision combined with incision, I object to a broad blunt pricker of whatever pattern, as the cambium is sometimes cut and often badly bruised by the broad blunt teeth as they are pushed into the bark. The rowel pricker has a lifting effect on the tissue, as it revolves and the teeth emerge from the wound ; thus my preference for a fine toothed pricker.

I made a push pricker with gramophone needles which I filed flat on two sides and fitted into a small block of wood about one-fifth of an inch apart. This size of tooth, in my opinion, answers admirably ; they make a fine puncture, and the flow of latex obtained by shallow excision and incision with this instrument was very satisfactory.

I would recommend shallow excision and incision with a fine toothed pricker on the half herring-bone system on one-third of the circumference of the tree. The half herring-bone system is simple and easily worked, and as simplicity should be aimed at, I prefer this method.

I should be glad to know the opinion of others on this important question.

Farming by Dynamite.

By

HAROLD HAMEL SMITH,

Editor of "Tropical Life."

While I have long suspected the possibilities of explosives in connection with agriculture, especially in the tropics, it has been only during the last twelve months that I have been able to satisfactorily demonstrate how very useful dynamite, and the other "ites" can prove, when used with discretion and by trained natives or Europeans. By their use both time and money can be saved, and better work done, both as regards the soil and the crops.

As regards the handling of these high explosives by natives, I would consider that any race or tribe which is intelligent enough to be trained to tap rubber trees, or extract pulqué from the maguey plant, as is done under the direction of white supervisors, could be trained to handle these explosives, drill the holes, and pack in the cartridges under the same class of white directors, as with the rubber tapping.

I did intend to devote my paper to "Rubber Seed Oil," a subject to which I have given a considerable amount of attention of late, but have chosen the question of "Farming by Dynamite" instead, as it is more widespread and international in character, and is of special interest to an Anglo-American Tropical Congress. On account of the now widespread use of explosives on cultivations, I would first state that if I do not include the names of the leading centers which have lately been using or experimenting with them for breaking up soils (some of the farmers in the western states of America have, I understand, regularly blasted their ground for twenty or thirty years past, and obtained bumper crops thereby), nor mention the names of all the leading journals that have been good enough to open their columns to discuss the matter, it is not for want of appreciation on my part, of the important share that they have taken in helping us to become "at home" with the use and handling of explosives, but for lack of space and time at my disposal and yours. I must, on the contrary, be far more brief than pleases me, for this is a subject which, the more it is discussed, the more one can realize what can be done with dynamite, and hence the more one would like to say on its use.

Dynamite or other explosives—and for the sake of brevity let me say "right here," that every time I use the word dynamite, I mean to infer "or other explosive if more suitable"—can be used with advantage in agricultural industries for the following reasons :

1. To break up hard or virgin soil to facilitate ploughing ; and especially to break up the under-crust, when present, which no plough could penetrate, at any rate no plough used by the average farmer or planter.

2. To blast out for removal, boulders, or rocks, and especially tree stumps, whereby not only is the risk of root disease removed, but, what is of great importance, the ground is left in a state to be easily and properly ploughed ; which otherwise would be impossible in a satisfactory manner, if the stumps or rocks are left *in situ*.

3. For clearing the soil of pests, destroying ants' nests, or rabbit warrens, etc., etc., as well as for regenerating and aerating hard or worn-out soils generally—as the sugar-lands on some of the West Indian estates which are not ploughed, but only hoed ; *i.e.*, the surface only scratched over, but the hard pan sub-soil is left year after year, and so becomes water-logged and airless ; hence dangerous.

4. For throwing up the soil for drains, especially deep gullies, and facilitating its removal by ploughs or hand.

5. For making holes for tree planting, and at the same time loosening the soil, which is a great advantage ; also for fence-post holes, or for setting uprights for buildings, etc., in position.

6. For well-boring, or well-torpedoing—*i.e.*, for increasing the flow from an artesian well by exploding a charge at the bottom of a well, to widen the aperture, and break up the ground, to let further supplies of water (or oil, if an oil-well) come through.

As time goes on, many other uses on the estates will no doubt be found, but as I do not pretend to have an exhaustive knowledge on the subject, I think I have said enough. Of course, I do not pretend to touch on the use of explosives for mining, since I speak only from the agriculturist's point of view; nor even of their utility for removing large masses of rock or soil for making estate roads, as the latter, although not uncommon, is too big and dangerous a task for the average planter, and should not be carried out without consulting an expert, one of whom nowadays is to be found at all large centers, especially in the neighbourhood of mines.

"It must not be thought that dynamite obviates the necessity of top ploughing," very truly points out the "Queensland Agricultural Journal." "Far from it. The plough must be used just as much as ever. The only difference is, that the dynamite expends its disintegrating force in the sub-soil, which is never touched by the plough, so that one is not merely planting the crops in the same soil year after year," but can, by its use, enable the crops to draw up their nutriment from below. Where clay sub-soils form a water seal, the use of explosives, if correctly applied, breaks up the clay strata and so allows the accumulated and stagnant water to pass through (at the same time the explosion kills myriads of harmful lives), and dissolving the plant foods in the lower, and hitherto inaccessible strata, liberates it in such form that it can be drawn up by capillary attraction, and pass through with the now non-stagnant water to be assimilated by the crops. May I remind you here—as I reminded the readers of my book on "Coco-nuts"—of the need of regular, adequate supplies of water at all times, if you want good crops. Water is necessary, and therefore should constantly be at the disposal of the crops (provided, of course, if not in over supply), to convey the plant's food in soluble form up to the crown. The quantity of such food assimilated or digested by the plant is roughly proportional to the amount of water which it absorbs—provided, of course, that the food is there to be absorbed; but the food alone is no use; without the water it cannot pass up the trees or plants and nourish them.

"Farming by dynamite," wrote the (London) "World's Work" last April, has gripped the United States and is spreading through Canada and Mexico like a prairie fire. "The farmers who have tried it, swear by it, and are upheld by the leading authorities in agricultural science." The "Queensland Agricultural Journal," already quoted, evidently found the same thing, for the editor writes. "Since the publication of our articles on the value of dynamite as an aid in clearing land, and to subsequent agricultural operations, judging by the numerous letters we have received from farmers and fruit growers seeking further information on the subject, much interest—we might almost say enthusiasm—has been aroused in many parts of the state in connection with the use of dynamite on the land"; while the "Times of Ceylon" quotes the following instance of its use for rubber planting by a Kelani Valley (Ceylon) rubber planter, using only ordinary dynamite cartridges: "First of all he used a quarter of a cartridge, then a half, and then a full one, and kept data of the area of ground disturbed when the quantities of dynamite had been fired. The plough only breaks up the top surface, so that the water mingles and dissolves the plant nutriment to a depth only of a few inches. The sub-soil, however, remains intact, and the roots of the crops have to feed upon what they can obtain from the land broken up by the plough. But breaking the land up by dynamite disturbs it to a depth of several feet, letting in the water which dissolves the essential nutriment, while the roots are able to descend to a greater depth and thus secure their fill of food. Again, the roots are allowed to grow downwards and not laterally; thus they do not encroach on the feeding areas of the adjacent trees, which is the case when there is only a top shallow layer of porous soil.

"The planter in question, we understand, has applied the new method to five acres of land and planted rubber trees therein. It is, of course, too early yet to judge the results in the growth of the plants. If the results are as good as anticipated it is very likely that the method will be widely adopted in Ceylon. The Red Cross dynamite was mentioned in the article which we quoted, but these not being procurable, ordinary dynamite cartridges were used in this case.

"Now that a local planter has started the method here," continued the paper, in its comments on the experiment, "it will not be out of place to quote one section of a recent article on the subject, which is of especial interest to planters: 'Possibly what at first sight appears to be the strangest application of dynamite is for the purpose of planting trees; yet its success in this connection is peculiarly remarkable. When a hole is made with a spade the surrounding soil is left in its hard condition. The result is that the roots find it difficult to start. They are cramped in the tight quarters of the hole and cannot pierce the surrounding hard wall of earth. Under these circumstances growth is appreciably retarded for a considerable time. With dynamite a large clean hole is blasted out and, in addition, the soil on all sides is loosened for five or six feet. When the tree is planted the young and tender roots force their way without effort through the crevices, sucking up nourishment, and commence to grow from the moment they are set, without any retardation whatever.' Those qualified to speak upon the subject are of opinion that this will bring trees forward at least a year sooner than those planted under the old conditions."

"A new profession has arisen of expert dynamite farmers," says "The Wealth of India," when commenting on the article in "The World's Work"; "dynamite is used for planting trees. The spade-made hole leaves the surrounding soil in a hard condition, and the roots find it hard to start. With dynamite a large, clean hole is blasted out, and the soil on all sides is loosened for five or six feet, thus enabling the trees so planted to grow twice as quickly as those set in the usual spade holes."

"We heartily commend the subject of 'Farming by Dynamite' to our readers"—writes the editor of "Grenier's Rubber News," at Kuala Lumpur, right at the heart of the plantation rubber industry in the Far East. "The consensus of opinion, at least among planters of the Federated Malay States, is that clean-clearing, which means the removal of all stumps and timber, is of paramount importance, and we feel sure that a perusal of the methods discussed" (in an article they published) "will convince planters that at last there is material available to accomplish the work expeditiously and economically."

"In South Africa," reports the "Home and Colonial Mail"—well known throughout India and the East—"experiments in ploughing by dynamite are becoming quite popular. It is claimed that operations can be carried out without injuring crops, and demonstrations are now taking place all over the Union with the object of fostering agriculture. The cost per acre is said to work out at between £2 10s. and £5 according to the nature of the soil and trees. Dynamite can be used for ditching, for constructing irrigation furrows, and other farming purposes."

All the leading papers in the rubber producing world, as well as those devoted to planting interests elsewhere, recommend attention to the use of dynamite for estate work. Its use especially appeals to me for out-of-the-way sections, and especially in Latin America, where the transport, even of the lightest make of ploughs, is difficult and costly, often impossible. In centers where the *tsetse* or other pest discourages the use of draught animals, the use of explosives should rapidly increase. Possibly the shocks, if not the actual explosions, might diminish the pests, especially if steps were taken to attract them to the spot by bait, in the shape of food to which they are partial. In locust infested soils, the numbers of these pests, at all stages, even when in flight, could be greatly reduced by organized explosions to greet them with a *feu de joie* whether in the soil as grubs or flying over it But there is no need to extend the list. You whom I am addressing are far more able than myself to think them out. I would, however, say in conclusion, that planters of coco-nuts, fibres, Ceará rubber, and other crops which can be grown to advantage, when scientifically cultivated, in almost semi-arid districts, will find the use of explosives a great aid as the following letter, written from Kalkudah, in the Eastern Province of Ceylon, to the editor of the "Times of Ceylon" (see their issue of June 20, 1912) tends to prove:

"I read with great interest the articles *re* 'Farming with Dynamite' in the 'Times of Ceylon.' I believe this method will gain popularity in the Eastern Province, as there is a slab of coral from the coast here to one-and-a-half miles inland, or further, and this runs from 2 to 9 ft. below the surface, in some places measuring 18 to 24 in. in thickness. It is not porous, but in some parts is soft and limy. There is water immediately below this slab, but the coco-nut roots cannot get to the water, and the trees are therefore greatly affected by the drought, and large sums of money have to be expended in watering plants. One notices patches of coco-nuts, old enough to give large crops, looking sickly, with not even a blossom on them. This is mainly due to the existence of this slab, which had not been broken through before planting out. Dynamite blasting will do more for these than tons of manure. A hole drilled in between every four plants through this slab and blasted with dynamite will crack up this slab, and enable the roots to find their way to the water, which is just underneath it.

"Again one finds that, after rain, the water remains in some places for weeks on the surface, affecting all the trees or plants in that area. This, too, would not occur if the slab were broken up, as the water would find its way through the cracks. In some places here, where this slab was broken through before planting out, the plants require very little watering, and the bearing trees are healthy and full of crop even during the severest drought. The method used in these places is to cut down to the slab and break it with pick-axes at a prohibitive cost. If holes could be drilled and dynamite used, the breaking up of the slab will be much greater and the cost less than half. Perhaps the cost of holing with dynamite and planting will be slightly higher, but there will be a great saving in watering, and the chances given to plants to strike root and bring them earlier into bearing will amply repay this. Even in bearing fields where this slab occurs it would be well to have it broken up a little and allow the roots to find their own water.

"It would be interesting to hear of results of a few experiments and also have the views of some of the veteran planters of the Eastern Province on the subject."

In conclusion, I hope to see further reports on the matter, not only over coco-nuts, but in connection with rubber-planting and tropical agriculture generally. Meanwhile there is no doubt that explosives have not only come to stay as a necessary auxiliary to modern agricultural science, but their use will extend on all sides until they occupy a prominent position therein.

Possible Rubber Producers in the Temperate Zone.

BY

CHARLES P. FOX.

This paper has been prepared at the suggestion of Mr. H. C. Pearson, originating from comments made upon an editorial in a recent issue of the "India Rubber World."

The idea of producing rubber in commercial quantities within the boundaries of the Temperate Zone is not a new one. The increasing use of this commodity and the increase in cost are responsible for the occasional stimulation of interest in the matter. Thirty years ago the farmers of Canada were forming companies for utilizing the common milkweed for this purpose. The high price of rubber in 1910 caused some Summit County (Ohio) farmers to seriously think of the same thing.

While the proposition is quite possible, its probabilities are remote, and dependent upon many conditions, some of which are: demand, cost of production, grade of product, influence of supplies of natural and plantation-grown rubber and the ever-appearing spectre "synthetic."

We have several rubber-producing plants suitable for the various sections of the temperate zone. During the past fifteen years the author has examined a number of plants, the examination including almost every plant likely to contain rubber, from Carolina Palmetto to California Cactus. For convenience I have grouped these plants according to their nativity and climatic requirements.

Of the foreign plants we have *Atractylis* and *Eucommia*.

Atractylis gummifera is a thistle-like Composita of Southern Europe with enormous beet-like roots and thorny leaves. A few years ago European writers advocated this plant as a source of crude rubber. Our examination did not confirm this view.

Eucommia ulmoides, known as the "Chinese Rubber Tree," is a native of Northern China, a country very similar in soil and climate to Eastern Washington. According to the Arnold Arboretum, Harvard College, it is perfectly hardy in New England. Just what it will do in this section in the production of rubber either in quality or quantity, is not given out by the authority quoted. Under natural conditions, it produces a good rubber, the rubber appearing as long silky threads in the broken bark. This source of rubber has been known since 1882. It has been recommended for planting by the Indian Forestry Commission. According to Vilmorin, Paris, who propagated it for sale, there was never much demand for it. It is a fine appearing tree and well deserves a place in ornamental forestry.

Of our native plants those of possible value as rubber producers in the North are members of the *Asclepiadaceae*, *Apocynaceae*, and *Compositae* families.

Of the true milkweeds there is only one of any importance, *Asclepias cornuti*. This species is very abundant throughout the United States, growing upon almost any kind of soil and showing great drought-resisting qualities. This plant contains an abundance of milky juice containing 3 per cent. of fair grade rubber. The cost to collect this latex is, however, prohibitory. The amount of product given up by extraction of either the fresh or dried weed is too small, and its character too inferior to command much attention.

If by selection or transportation from one section to another, the quantity and quality could be increased and improved to a degree sufficient to make the production by extraction profitable, this plant would be the favorite, as perennial plantations yielding annually 2 to 3 cuttings of at least 10 tons each per acre of green weed, could be easily and economically established.

The common Indian hemp, *Apocynum cannabinum*, occupies about the same territory as the milkweed but is less abundant. It produces less latex than the milkweed, but the quality of rubber is better. The root of this plant contains rubber, and is very similar to that of the African *Landolphia*.

The native *Compositae* of this region give us several rubber producers. *Souchus* (Sow thistle), an introduced species now naturalized, is credited by Jumelle as the producer of an excellent grade of rubber. *Souchus* rubber is the subject of a German patent of 1885. This plant thrives on a dry, barren soil and is regarded as a troublesome weed.

We have two species of wild lettuce, *Lactuca Canadensis* and *L. virosa*; both very abundant, especially the latter, which is a terrible pest. Both produce thick rubber-containing latex and medicinal agents. *L. virosa* gives a water extract similar to chicory as a coffee substitute.

The arid section of the Temperate Zone is amply provided for with guayule, pingue, greaseweed and candelillia.

The value of the guayule (*Parthenium argentatum*) as a rubber producer is too well known to need a description. Prof. Lloyd is certain that guayule can be successfully grown in Mexico. Mexican conditions can certainly be duplicated in the Southwest.

Pingue (*Actinella Richardsonii*) is a related plant found in New Mexico and southern Colorado. While containing less rubber than guayule, it possesses some superior advantages in other ways. The root of the pingue is the producing portion. The top furnishes numerous shoots for propagating. The pingue requires a deep, sandy soil for the maximum development of its long tap root. Under these conditions the yield of rubber may reach 7 per cent. of good grade rubber equal to, if not better than, the guayule product.

While investigating the pingue, this peculiar condition was observed: As before stated, the pingue, under natural conditions, *i.e.*, mountain slopes and dry sandy banks, develops a fusiform type of root, comparatively rich in rubber. On clay soil, in meadows along irrigating canals, the pingue root becomes fibrous and contains little or no rubber. This phase may have an important bearing upon the utilization by cultivation of the guayule and pingue for the production of rubber.

The neglected mariola, another *Parthenium*, occupying a wider range and much more abundant than guayule, may sometimes be of value on account of its resin. Nevada greasewood contains rubber as shown by the Ellis & Werner patents of 1902. Mr. Sam P. Davis, Nevada Industrial Commissioner, advises that there is a large amount of this plant.

Another promising plant of the arid region is "Strockles Rubber Bush," a robust *Composita* growing abundantly throughout the Great Basin. While the rubber of this plant is inferior to that of the other two *Compositae* mentioned, it can be utilized. This plant also contains a large amount of valuable resin.

In North Mexico and the "Big Bend" country of Texas, there is an immense growth of Candelillia, an *Euphorbia* which contains rubber and wax. This wax is now a commercial product much used in Germany as a constituent of hard rubber. On account of its drought-resisting qualities and the facility by which it can be propagated by its bulbous root, it should be a valuable plant for the extremely arid, non-irrigated section of the Southwest.

The South has its special rubber producing plants. Some 15 years ago the growing of *Ficus elastica* for rubber was attempted in Florida. The point selected, unfortunately, was on Key West, a small island near the mainland, with shallow soil and dry meteorological conditions.

The venture was not successful. The ruins of the plantation with its dwarfed, straggling trees still remain. The trees are now 15 to 20 feet high and 6 inches in diameter. Some of these trees were tapped in April, 1910. Very little latex was secured and this was of poor quality. When grown on the mainland, in the deep, fertile and moist soil near Miami, it becomes a large tree.

There is a native fig (*Ficus aurea*) found growing abundantly throughout southern Florida. Large trees, 60 feet high and 2 feet in diameter, of this species, are to be seen on the grounds of Fort Dallas, once the prison home of the defiant Seminole chieftain, Osceola.

Mr. Flagler, the founder of Palm Beach, planted this species along the shores of Lake Worth for ornamental purposes. The tree gives an abundance of latex containing rubber, of quality probably as good as the Amate rubber of Mexico. The tree will flourish in almost any situation found in South Florida.

That portion of Florida south of Homestead is a vast stretch of saw grass, with swampy clay of doubtful value for agricultural purposes, even after the "Everglade Reclamation" has been completed. The Florida fig will grow there. Considering the large area suitable, the rapid growth of the tree, and the possibilities of the yield of rubber, the proposition is not the worst one.

In the sandy and drier portions of the South, we have several species of *Bumelia*. Tropical relatives of the *Bumelias* are producers of gutta percha. Texas "stretchberry" (*Bumelia lanuginosa*) contains rubber. The "stretchberry" is a shrub of wide distribution suitable for much of the waste land along the Pecos.

In the arid portions of the South, especially on the Florida Keys, the hedge spurge (*Euphorbia triangufolia*) does entirely too well. Planted out originally for fencing, it has, in many localities, spread into the fields. This plant produces a small amount of rubber. Recently, it has been strongly advertised as "Cuban Rubber." Value of the plant as a rubber producer has been over-estimated.

Of the several plants mentioned for the possible production of rubber in the Temperate Zone, only two of them, guayule and pingue, have been found to contain enough rubber to insure a profitable working. The balance must be improved by careful "Burbanking." This work of selection and improvement lies within the scope of our experiment stations. Already the universities of New Mexico and Arizona have work in progress along these lines.

In the possible production of rubber in the Temperate Zone, the arid West has the better chance, with the South a close second. While the Temperate Zone may never do much in the way of producing first class rubber, the firm believer may find consolation in the prophecy that, if necessity demands, it can produce enough masticatory to keep busy a hundred million maxillae.

Commercial Possibilities of Synthetic Rubber.

By

LOTHAR E. WEBER, Ph.D.

It is rather peculiar that although the conversion of isoprene into a rubber-like substance has been known for upwards of twenty years, further progress in this direction has been practically stagnant until recent date. This is not altogether due to lack of effort, but rather to the enormity of the problem. The synthesis of rubber, however, received a new impetus about three years ago when two German chemists, Hofmann and Harries, working independently, succeeded in obtaining almost simultaneously products which gave the chemical reactions of rubber and had certain physical resemblances to the natural product. Since then considerable progress has been made in this direction, and, more recently, stock companies have been formed and capital subscribed with a view to actually placing synthetic rubber on the market. The daily press, both in this country and especially in Europe, gave this latest development of synthetic rubber wide publicity, sharing the optimism of the promoters and inventors of the new process, and as a result the general public and, to a very large extent, rubber manufacturers themselves, have been led to believe that synthetic rubber can in the near future be manufactured in competition with the natural product.

I do not want to give the impression of holding in light regard the magnificent work which has been accomplished by European chemists in their efforts to synthesize rubber. I almost think that a certain amount of chemical training is necessary to appreciate the innumerable difficulties and pitfalls which face the investigator in these fields. These men deserve the profoundest admiration for their painstaking and laborious efforts, but it is greatly to be deplored that the public was given to understand that synthetic rybber is to-day a commercial possibility, since, if the promise is not fulfilled, the attitude of the public will scarcely be one of admiration.

Synthetic rubber enthusiasts have been very fond of comparing the synthesis of rubber with the synthesis of indigo, asserting that the same fate awaits natural rubber that befell natural indigo. These two problems however, have very little in common and differ from each other in such striking respects that the two syntheses are not capable of comparison. I should like to take up this comparison in more detail because I think in this way the difficulties which will prevent commercial synthetic rubber becoming a realization during the next few decades can be more clearly shown. Before doing so, however, I would ask your indulgence in attempting to make clear to those of you who are not chemists, the meaning of a rather formidable looking word which is always in evidence whenever there is any mention of synthetic rubber. I refer to the word "polymerization."

We are being continually informed that isoprene polymerizes to rubber and that the process of converting isoprene into rubber is one of polymerization. The process of polymerization briefly stated, is one whereby a large number of small units combine to make a single large unit. It is essentially a process of agglomeration. This process of agglomeration takes place between the molecules, the latter, as you know, being regarded as the smallest amount of substance that is capable of existence. The molecules of isoprene, at least 100 of them, unite and polymerize into one single molecule of rubber. Unfortunately, we have not the least idea exactly how many isoprene molecules go to make one molecule of rubber, and it is probably certain that the natural rubbers themselves vary very widely in the respect of their degree of polymerization. It does, however, seem probable that the higher the degree of polymerization; that is to say, the more the number of isoprene molecules that unite to form one rubber molecule,the better are the physical properties of the rubber. In other words, two rubbers of exactly the same chemical composition, with different physical properties, owe this latter difference to their different degrees of polymerization. It follows, then, that a uniform degree of polymerization would be the first requirement for a synthetic rubber.

Unfortunately, the chemist of to-day is absolutely powerless in determining this degree of polymerization experimentally and, to a certain extent, of controlling it. For instance, it is not possible to go into a laboratory with a quantity of isoprene and polymerize the latter to any desired extent. In fact, we have no means of feeling sure that we can on two different occasions bring about the same degree of polymerization. With the chemical methods available to-day it would be absolutely impossible to make a product with an assured uniform degree of polymerization, and until this is possible, I fail to see how there can be any possibility of commercial synthetic rubber. The first requirement of such a product is uniformity of polymerization, but as we have no means of determining this uniformity, or lack of it, variations would be bound to occur which would make the employment of such synthetic rubber by the manufacturer altogether too precarious. We all know to what disagreeable results variations in the uniformity of the natural product lead, and in the latter case the possibilities for uniformity are infinitely more favorable than in the case of the synthetic product.

Now let us briefly consider the case of indigo. Here the problem was to manufacture an article of absolutely definite characteristics and properties. It undoubtedly required a vast amount of chemical skill before the composition of indigo was determined, but once this important feat having been accomplished, the chemist had a definite conception of the substance to be synthesized. Furthermore, there could never be the least doubt as to whether the investigator had actually succeeded or not in obtaining indigo. It is the work of only a few moments to be able to definitely decide whether a product is indigo or not. In the case of rubber the state of affairs, as we have seen it, is totally different. In the first place, the methods of polymerization are still in their infancy; we have no means of controlling its magnitude, or of assuring its uniformity. The chemical methods of to-day are wholly insufficient for the solving of this problem.

Synthetic rubber enthusiasts have either overlooked or ignored with supreme indifference the very important fact, that in the year 1916 the price of raw rubber must of necessity drop very considerably. It is estimated (and from all accounts the estimate is a conservative one) that by the year 1916 the Eastern plantations alone will be able to produce 100,000 tons per year, although there are two factors which have not been taken into account in making the estimate, which might have a very serious effect on the future of the plantations. These two factors are: first, diseases of the trees, and secondly, the labor problem.

The chances of the trees becoming infected either with a disease or insect pest is probably very small, as the bulk of the plantations are under very careful supervision, and special precautions are being taken to prevent such an occurrence. The labor question seems to be of more serious consequence, as the Malay coolie is of a rather independent nature. Nevertheless, it is highly probable that the estimate is not exaggerated. Even to-day one repeatedly hears statements being made that the plantations that are producing rubber could, if necessary, put their product on the London market at 25 cents per pound. This is possibly slightly exaggerated, but not very much so. One has only to look at the dividends now being paid by some of the Eastern plantations to realize that there is a certain amount of truth in this statement. As things stand to-day, supposing it were possible to market synthetic rubber at 50 cents a pound in great quantities, the competition with plantation rubbers would not be very noticeable, as their output is relatively small; but in 1916 the case will be quite different. Even supposing that the demand for rubber keeps on increasing, the plantations will still be in a position to supply at least half the demand. There are, furthermore, enormous opportunities for the plant physiologist in the cultivation and production of rubber. So far very little has been done in this direction, as the plantation industry is still in its infancy; but it seems more than probable that careful experimentation will enable means to be devised whereby the yield of rubber per tree can be materially increased.

In the case of the sugar beet this increase in the yield has been accomplished with surprising success. It has been possible by careful methods of cultivation and selection of the most advantageous conditions of soil, to raise the yield of sugar in the beet from 3 to 18 per cent. Undoubtedly, in the case of rubber, the problem is more complex than in the case of the sugar beet, but this field of investigation is still waiting for the pioneer, and I cannot help feeling that the possibilities are indeed large.

It must be seen, even on the supposition that synthetic rubber were to-day a commercial possibility, and that an article could be produced equal to the plantation product, that the struggle for commercial supremacy would necessarily be a fierce one, with the advantage very much in favour of the plantation product.

In the case of indigo, the synthetic product had practically no competition to meet whatsoever. The production of natural indigo had been carried out under the crudest possible fashion, and the methods of obtaining the dye from the plant were even more crude. For some extraordinary reason, although the production of this dye stuff was of such extreme value to the textile industry, it always remained in the hands of the ignorant natives. Had the same amount of energy and skill been applied to the indigo plant that is now being applied to plantation rubber, the victory of synthetic indigo would probably still be in doubt. It must be granted that the commercial synthesis of indigo was the crowning technical achievement of the nineteenth century, but it must also be acknowledged that its fight for supremacy over the natural product was materially aided by the shortsightedness of indigo planters. Rubber planters, on the other hand, have been keenly alive to the large possibilities which are to be derived from scientific methods of cultivation and production, and they have got such an infinite lead over the efforts of the synthetic chemist, as to be in little danger of being vanquished for many decades to come.

I hope I have not been altogether unsuccessful in making plain some of the difficulties that confront commercial synthetic rubber. With our present-day chemical methods it would be well nigh impossible to assure a uniform synthetic product. Within the next few years the Eastern plantations will be in a position to supply half the demand for rubber, and accordingly would be in a position to wage a very stubborn fight against any synthetic product. Finally, it seems more than probable that scientific investigations will enable the planter to increase the yield of rubber per tree, and thus put him in a still better position to combat the synthetic article.

I do not want to make such a rash statement as to assert that synthetic rubber will never be a commercial possibility, but I should be greatly surprised if there is anybody engaged in the rubber industry to-day who will have the opportunity of seeing synthetic rubber in open competition with the natural product.

Problems in Vacuum Drying.

By

J. P. DEVINE.

In the selection of a topic for discussion I rather reluctantly, and yet from necessity, selected one that is intimately identified with the business in which I am engaged, and my remarks may at times seem somewhat personal. Among so many who have devoted their time, ability and energy to solving the many intricate problems in the cultivation and production of crude rubber, as well as to improving and refining methods and processes of manufacture of the ever-increasing number of articles—the product of rubber—I can assure you that my limitations are not an unknown quantity.

My introduction to and connection with the rubber industry was made about ten years ago when I sought to interest manufacturers in this country in a new method of drying rubber. I found, however, that the manufacturer was disposed to be quite satisfied with the then existing method and did not hesitate to forcibly express his views and opinions as to any improvement in the drying process by shortening the time or otherwise, except by sacrificing the quality of the rubber and thereby jeopardizing the standards that years had taken to establish.

I had been convinced that Vacuum Drying Apparatus possessed unusual merit for economically and thoroughly removing moisture from materials and particularly where it is desired that the final traces should be removed; as is necessary in rubber and rubber compounding materials, I was ready to and did back my judgment by my reputation and resources for its introduction in this country. Notwithstanding the discouragements of my early efforts, I made investigation as to methods of drying rubber, and learned that little, if any, advancement or improvement had been made up to that time, and this confirmed my opinion of the value of the vacuum process, and I have maintained ever since its introduction that the vacuum drying process and apparatus introduced in this country by myself, would be and has since proven of inestimable benefit to the rubber industry.

For years rubber was dried by any means convenient at hand that would not represent an expenditure of capital, the boiler room or a room adjacent thereto serving the purpose, until the effects of the elements upon the rubber began to receive attention and study. And then, the improvements consisted largely in the construction of drying lofts, the racks on which the sheeted rubber was hung and the distribution of heat by coils, or by circulation of hot air by means of fans and blowers; little regard, however, being given to temperature or length of time of the drying process. Until the introduction of the vacuum drying apparatus this primitive method was still in use, and occasionally an advocate is still found who asserts that the hot air method is necessary for the proper curing of some particular grade of rubber. The fallacy of such assertions is proved by the use of the vacuum apparatus drying every grade of crude rubber, and I shall endeavour to make clear to you the claims I make for the superior quality of rubber dried by a properly designed and constructed vacuum apparatus.

While it is true, considerable thought was given to improving processes for drying rubber, there were no striking departures from the antiquated method of using hot air as the heating medium. The dust and dirt that would settle upon the rubber were the least of the evils; the construction of special drying rooms from which direct sunlight was excluded, and provisions to eliminate dust and dirt, and the regulation of temperatures for various grades of rubber, as well as the attempt to dry the air before being admitted into the drying room, all contributed to avoid the deterioration of the rubber by such means; but the value of these improvements was doubtful, as they only tended to reduce the effect of high temperatures with a consequent prolongation of the drying period. The fact is that the two insidious enemies of rubber are heat and oxygen, and these elements are, and always will be, present, and necessarily so, in any system of hot air drying. They are deteriorating agents, and their elimination is most essential for the proper drying of rubber. Their elimination by the vacuum apparatus has proven the superiority of the vacuum-dried rubber in the processes of its manufacture.

Another and serious objection to the hot air system of drying rubber is, that rubber as it comes from the washing machine contains a very large proportion of mechanically bound moisture; while this is readily given off in the hot air drying room, its expulsion causes a contraction of the rubber, which, with the oxidation constantly taking place, causes a hardening of the surface that prevents the elimination of the last moisture within the rubber, except by a very prolonged drying period, during which time the rubber is further subjected to oxidation and not unlikely to excessive heat. Unless the last traces of moisture are eliminated, " blowing " is sure to result during the following stages of its manufacture.

We still hear occasionally about " curing " rubber; but in reality this is simply the removing of the final traces of moisture; as stated, under atmospheric conditions, this can only be accomplished by a prolonged drying period, while under vacuum the rubber is thoroughly dried in a very short time, and in practice rubber is immediately worked up after removal from the vacuum dryer.

The deteriorating agents—oxygen and excessive heat—can be eliminated only by the vacuum process and apparatus. This process and apparatus alone afford the proper conditions to dry rubber rapidly, uniformly and thoroughly at a low temperature and without oxidation, independent of climatic conditions.

It must be borne in mind that under atmospheric conditions a rapid boiling can only take place at 100 degs. C. or 212 degrees F., and that as the temperature decreases, the drying time is extended; while under vacuum the boiling point is greatly decreased and increasingly so as the barometric reading is approached. To illustrate, under a vacuum of 29 in. water boils at 25 degs. C. or 77 degs. F. Rubber dried in the vacuum chamber, while the first free water is being removed, will not need to be heated, practically, above the boiling point of water at that particular vacuum. As the moisture is evaporated from the rubber, naturally the temperature of the rubber being dried tends to increase; to prevent any overheating the supply of the heating medium—steam or hot water—is regulated accordingly and entirely shut off before the final drying; the last traces of moisture are therefore drawn off by the latent heat in the dryer accelerated by the high vacuum. Because seemingly high temperatures are used at the beginning of the drying process to expedite evaporation, the erroneous impression is sometimes formed that the rubber is overheated in the vacuum chamber; but in a properly constructed vacuum chamber with its auxiliaries—condenser and pump—properly balanced, the application of well-known physical laws absolutely prevents any overheating, if only reasonable care is taken in its operation.

Then, too, the drying process taking place under a high vacuum in the absence of oxygen, oxidation cannot take place. The rubber not being overheated nor impaired by oxidation has greater elasticity and tensile strength, and accomplishes that which is the aim of every manufacturer—to obtain the greatest yield when being made into final product.

As different grades of rubber must be subjected to varying temperatures, the temperature of the heating medium is easily regulated without over-heating or materially affecting the drying time ; so that the vacuum process offers many advantages over the old method of drying rubber, whether it be fine Pará or Pontianak.

Another very great advantage of the vacuum process lies in the fact that as the drying period is only a few hours, varying according to grade of rubber, the crude rubber can be washed, dried and processed in a fraction of a day ; consequently there can be no deterioration after drying and before using—as it is well known that washed rubber oxidizes very rapidly—and there is no danger of the final manufactured product being porous or spongy, due to the presence of moisture.

The rubber industry has expanded tremendously in recent years, owing to an ever-increasing variety of products in which rubber is used. To meet the daily factory demands for large quantities of crude rubber of different grades, the use of the old method of drying is disadvantageous and unsuitable, as well as excessively expensive.

In an average establishment of to-day, making a general line of rubber goods, two tons of crude rubber is a conservative estimate of its consumption. If the old hot-air method is used, in order to properly and thoroughly dry the washed and sheeted rubber, six weeks are consumed in the drying process. Seventy-two tons of rubber would be hanging in the drying lofts, which at $1 per pound, would represent an idle investment of $144,000 on raw material, the carrying charge at 5 per cent. amounting to upward of $20 per day ; and should the carrying charges, for instance, factory space, etc., be included, the above sum would be greatly increased.

The same quantity of rubber could more thoroughly and permanently dried by one or two vacuum chambers in a day of ten hours, so as to " work up " whatever grade may be required for each day's output, and the initial cost of such an installation would be less than the cost of the old-fashioned drying rooms for the same quantity. So that the vacuum chamber pays for itself in the savings on investment, carrying, insurance and other fixed charges on raw material, as well as gives a flexibility to the factory for its daily production that cannot be obtained by any hot-air method.

To illustrate the great saving in factory space, a vacuum drying chamber having a capacity of approximately two tons of dry sheeted rubber per 10 hours, occupies a space of 8½ feet high, 15 feet wide, by 9 feet long ; and its auxiliaries, the condenser and the pump, can be conveniently located at any place in the factory in proximity to the dryer.

In addition, the vacuum drying process offers further advantages over the hot-air system because of the other factory economies derived by its use. The drying expenses for a hot-air system for steam consumption and attendance are enormous. It is an established fact that by any hot-air system not more than one-third of the heat units supplied are utilized in the evaporation of moisture ; whereas by the vacuum process practically every heat unit is transmitted to and comes in direct contact with the material being dried. The saving of fuel is consequently most considerable not only on account of the very much shorter drying time—reduced from weeks to hours—but because of the much higher efficiency of the heating medium used in the vacuum drying process.

The vacuum drying apparatus is constructed of cast iron and is practically indestructible ; there are no appreciable maintenance charges and fire hazards are eliminated.

As to attendance, only one operator is required to operate the vacuum dryer, who, while one charge is being dried, is engaged in filling the second set of trays with rubber for the next charge, and in re-charging the apparatus replaces each tray of dried rubber with one of wet.

A vacuum drying apparatus consists of a vacuum drying chamber, which should be constructed of a special grade of close-grain homogeneous cast iron, equipped with heating shelves made of hydraulically straightened sheet steel plates. I emphasize that the plates should be hydraulically straightened, as by this means only can a uniform even and flat surface be secured on which the trays are placed and which will withstand the strain of the varying steam pressures used during the drying process. It is important that the heating shelves are so constructed as to insure an even surface, as any distortion of the heating shelves will cause the trays to rest uneven and thereby permit an unequal transmission of the heat to the material being dried.

Connected with the vacuum chamber is a condenser, and it is most important that this auxiliary be of proper condensing capacity for the vapors given out during the drying process. In the determination of the size of the condenser, somewhat complex problems arise, for not only must the volume and speed of such vapors be determined, but the proportion to be condensed during the early stages of the drying process must be determined, when the free or mechanical moisture is driven off; and in this connection, there must also be considered the temperature of the cooling water available for condensing purposes. These elements cannot be determined by any "Rule of Thumb Method," but must be carefully calculated. The size and capacity of the dry vacuum pump is of equal importance to the well balancing of a vacuum apparatus; for in order to secure the highest efficiency it is necessary to create the highest obtainable vacuum as quickly as possible, and when obtained to maintain a uniform vacuum throughout the drying period.

Complaints have occasionally been made by some people who have attempted to dry rubber under vacuum that such vacuum-dried rubber was not satisfactory, and the blame was promptly put on the vacuum drying apparatus and process. I may state that though these complaints were, of course, *bona-fide*, the cause for such complaints was misplaced. The vacuum apparatus and process have the advantage of working almost automatically and require scarcely any attendance; but these advantages have in the above-mentioned cases been abused, and of course not without detrimental effects to the vacuum-dried rubber.

To illustrate what I mean, a certain size of a vacuum apparatus is intended to receive a certain quantity of rubber per charge, and naturally the heating surface of the dryer, which is equivalent to its drying capacity, has, as I have stated, to be most carefully calculated for this purpose, and if the instructions for operating such apparatus, which are most simple, are only followed, it is a physical certainty, I might say, that the vacuum-dried rubber will be satisfactory and far superior to air-dried rubber, because with a vacuum apparatus and process nothing is left to chance or climatic conditions.

In cases, however, where complaints have arisen, the well-meaning people who were using such a dryer, being surprised at the capacity of the apparatus far exceeding their expectations, thought it right to go a little further by further increasing the charge of rubber and ultimately loading the apparatus with a much larger quantity than their apparatus was intended for. Of course, it was soon found that the increased charge could not be dried in the stated time, nor with the stated temperature of heating steam. As it is only human not to decrease one's desires, the natural human remedy was resorted to, that is, an increased temperature of heating steam and also a prolonged drying time. If you consider that the heating surface at a certain temperature within the dryer is intended for a layer of rubber of a uniform and certain thickness, its capacity, or rather the beneficial results obtained therefrom, will be destroyed, or at least impaired, by an increased quantity of rubber per charge and an increased temperature of heating steam, because the heating surface itself remains the same; and it is this factor which remains constant—that upsets the results sought to be obtained by the violation of well known, but not considered, natural laws.

Experience has taught us to balance the necessary heating surface, to transmit a certain temperature to a certain layer of material to be dried; and it is quite erroneous to argue—though a common mistake—that the same beneficial results may be obtained from a larger quantity of material, by simply increasing the thickness of the drying material and increasing temperature, in the belief that the above-mentioned factor would increase proportionately. This, however, is not the case, as I will more fully point out.

If one takes the conductivity of rubber alone into consideration, and the gradual but decreasing evaporation of the water contained therein, it can very easily be understood that by altering some of the factors, the physical laws, on which our calculations are based, will be violated without any such intention, and the penalty will be an unsatisfactorily dried rubber—the cause of which is naturally placed at the wrong door. The fault is not in the apparatus, but in the method of its operation. The same remarks refer to the auxiliaries of an apparatus for drying rubber. These auxiliaries consist of a condenser and vacuum pump which are both calculated to correspond with the capacity of the vacuum apparatus they are intended to serve.

To illustrate what I mean: A vacuum dryer of a certain drying capacity and calculated for a certain purpose is intended to evaporate a certain quantity of water in a given time, and of course, which is essential, at as high a vacuum as is possible under practical working conditions. All this is, to a great extent, based on practical experience with the very material our apparatus is used for. If, however, the condenser, instead of handling the quantity of vapor for which its cooling capacity is calculated, is burdened with ever so much larger a quantity, the result must be detrimental in two ways: it not only re-acts on the dryer and the product it is supposed to turn out regardless of the time, but also re-acts on the working of the pump.

As regards the vacuum dryer, it is essential to have its inner space continuously freed from the vapor arising from the drying material in order that no inner pressure may be created in such apparatus to lower the vacuum. This can only be done by having the arising vapors taken care of in their entirety during their passage through the condenser, the capacity of which cannot be changed at will.

If more vapors are created than the condenser is intended for, such vapors will partly remain in the dryer, and create inner pressure. The inner pressure thus created consequently reduces the vacuum in the dryer, and as a consequence the boiling point of the water contained in the rubber is increased, and the rubber will be heated up to a temperature never intended, with detrimental effects to its quality. The overcharging, as I said before, affects the efficiency of the pump and prevents it from creating the desired high vacuum. The reason for this is that a dry vacuum pump—the only type we have in mind in this discussion—is intended, dimensioned and constructed for pumping air and not vapour, particularly as the latter expands so enormously under vacuum. If the pump were intended to exhaust rarified or expanded vapor in addition to rarified or expanded air, its dimensions would be so enormous as to make its use practically impossible.

If, therefore, the dry vacuum pump has to exhaust vapors which have passed uncondensed through the over-taxed condenser, a burden is placed on the pump for which it was never intended ; its work becomes inefficient and most naturally impairs the vacuum and efficiency of the whole installation for drying purposes.

I have but briefly outlined some of the factors which have to be taken into most serious consideration in designing and constructing a proper vacuum dryer and its auxiliaries. I submit that it is wrong and unfair to subject apparatus to work for which it is not intended, and to charge the inefficient or insufficient results of such an abused vacuum drying installation at the door of the principles of drying under vacuum, viz. : rapid and thorough drying at a low temperature.

Owing to the remoteness of plantations and the difficulties surrounding the transportation of machinery and appliances for removing impurities, only primitive and unscientific methods of preparation could be adopted. The use of the vacuum drying process was, in consequence, first introduced and adopted by the manufacturers to dry washed rubber. In recent years, however, much greater thought and study have been given to the preparation of the crude rubber on the plantation. Especially is this noticeable in the quality of the rubber reaching the market from the Malaysian Straits Settlements and Congo Plantations, where vacuum drying apparatus has been installed and is found to be of great value. This is somewhat reflected in the moisture content of plantation rubber that reaches the market with a low percentage of moisture, as compared with 15 per cent. or more in Upriver Pará. There can be little doubt that in the future the planter will understand that the price is based upon actual rubber, and he will serve his purpose best by adopting the very latest method for the treatment of the raw material so as to free it from impurities and to reduce its moisture to a minimum percentage. Pure and dry rubber does not suffer in transit through fermentation caused by vegetable impurities and moisture. This improved quality of the raw material will not cause the discontinuance of the drying process in the factory. It will, however, tend to restrict the operation for the treatment of such rubber to remove the final percentage of moisture only, and thus simplify factory operation.

The highly satisfactory results to the manufacturer and planter from the scientific and research work in the laboratory have contributed materially to the advancement of the industry, and its further progress can and will be accomplished by a closer and more intimate relationship between the manufacturer or producer and the appliance manufacturer. We are, after all, in our several activities dependent one upon the other, and why not recognize our mutual obligations to co-operate, that a maximum productiveness by newer and better methods may be secured ?

Lithopone and Oxide of Zinc in the Rubber Industry.

By

G. C. STONE

AND

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of the New Jersey Zinc Company.

The zinc oxide of commerce is a white amorphous powder, the purity of which depends entirely on the character of the ore from which it is produced. Zinc ores, with the exception of those from Franklin Furnace, New Jersey, contain considerable lead and usually cadmium. For the production of a white oxide, suitable for rubber compounds, the presence of these constituents except in very small quantities is inadmissible, especially when the object is to make as white a product as possible. The necessity of avoiding the presence of lead and cadmium, which are the only volatile constituents of the ores other than zinc, insures unusual regularity in the composition of oxide of good color. For example, the oxide made by the New Jersey Zinc Co. contains upward of 99 per cent. of zinc oxide. The principal impurities are small quantities of carbon dioxide and sulphur trioxide.

Zinc oxide is made by two processes, known respectively as the direct, or American, and the indirect, or French. In the direct process the zinc is driven off from the ore by the reducing action of carbon at a high temperature, and the zinc vapor burned direct to oxide. In the indirect process the ore is first smelted to produce metallic zinc, or spelter, and this metal is then burned to oxide. The latter process is naturally more costly than the former, and the products made by the two differ in certain material points.

Direct Process Oxide: The grades used in rubber compounding are "XX" (red brand) and "Special" (red brand). The difference between the two is mainly one of color, the Special being more desirable when the whiteness of the compound is important.

Indirect Process Oxide: These are graded as "Red Seal," "Green Seal," and "White Seal." They are of a purer and brighter white than direct process oxides. The Green Seal oxide is smoother and of a more perfect white than the Red Seal. The White Seal is a comparatively new product, and is characterized by its remarkable lightness and bulkiness. While Green Seal and Red Seal oxides are packed 300 pounds to the barrel, White Seal can only be packed 150 pounds to the barrel. The exact meaning of this difference will be discussed later in this paper.

Chemical and Physical Properties of Oxide of Zinc: In general, the first essential of a zinc oxide for rubber purposes is, as indicated above, purity. The presence of serious amounts of metals that yield colored sulphides is entirely inadmissible, as during the process of vulcanization these sulphides are formed and discolor the product. Further, in rubber compounds it is in the first degree desirable that the compounder should know exactly what he is using if he is to get good results. Uniformity of composition, therefore, is very desirable.

The determination of zinc is a rather difficult matter, and the analytical error involved is frequently of such magnitude in comparison with the amount of impurity present as to make the determination valueless. Even in experienced hands the error is rarely less than 0.25 per cent., which, taken in connection with a zinc oxide content of over 99 per cent., obviously vitiates any attempt to determine the amount of impurity present by difference.

We believe that users of oxide will be well advised to confine their analytical work to simply testing for adulteration and to ascertaining the suitability of an oxide for a particular purpose by a practical compounding test in the laboratory, rather than to spend much time and effort in attempting to determine the zinc contents of the oxide. This mode of procedure we understand is in vogue in the majority of rubber laboratories.

Zinc oxide should dissolve in dilute hydrochloric acid without effervescence and without smell, and should leave no appreciable residue. On the addition of ammonium chloride to the solution and then an excess of ammonium hydrate and ammonium carbonate, the liquid should remain perfectly clear, or show at most a slight cloudiness. Care is needed in carrying out this test, as a considerable excess of ammonia and ammonium carbonate is necessary to dissolve the carbonate of zinc first formed. If the solution in hydrochloric acid has been performed in a test tube, it is desirable to transfer the liquid to a beaker before proceeding with the addition of ammonium chloride, etc.

Having regard to the nature of the process by which zinc oxide is made, positive results, as for example, a residue insoluble in hydrochloric acid, indicate either a leaded oxide, which is unsuitable for rubber purposes, or wilful adulteration.

Commercial zinc oxide consists of extremely small particles, so small in fact, that it is doubtful if they can be seen under the ordinary microscope. These small particles always form more or less coherent aggregates, which are apparently somewhat of the nature of a slightly elastic sponge entangling considerable air. These aggregates are what we see and speak of as the particles of zinc oxide. The tendency of an oxide to cohere in this way can be to a considerable extent regulated during the manufacture. In White Seal oxide, for example, the coherence is much slighter than in any of the other brands, which makes it necessary to pack only 150 pounds to the barrel. By forcing in a larger quantity this property can be partially destroyed.

It is necessary to distinguish clearly between the degree of coherence of an oxide and the true specific gravity, because the two properties are not infrequently confounded under the term "density." Broadly speaking, all amorphous oxides have the same specific gravity, the variation being fractional and the mean figure in the neighborhood of 5.6. This means that the zinc oxide itself, disregarding altogether its state of aggregation, is 5.6 times heavier than an equal volume of water. If, however, we take a box having a capacity of 1 cubic foot and weigh it full of White Seal oxide, and afterwards full of Red Seal oxide, being careful not to compress the oxide in the box, we shall obtain a greater weight in the latter case than in the former. This means merely that there is more air entangled in the White Seal than in the Red Seal. It must be borne in mind that this property of entangling and holding a larger quantity of air is associated with the character of aggregation and compactness of the oxide groups, and that this latter condition has a decided bearing in the application of the oxide for some purposes.

It is possible to make a series of zinc oxides varying from solid crystals large enough for the form to be clearly visible to the naked eye, and which sink in water like stones, to the very light form known as "philosopher's wool," which floats in the air like thistle-down. All, so far as tested, have the same specific gravity, but the great variations in the amount of entangled air causes an enormous variation in the apparent densities.

The determination of the actual specific gravity is not an easy matter, and considerable care is necessary. The oxide tends to retain its entangled air very obstinately, and the use of a good vacuum pump is necessary to insure that the air has been completely expelled.

Owing to its extreme fineness it is useless to attempt to size oxide of zinc by any system of screens. Screening is, however, often useful to break up the aggregates formed. This can best be done in a bolting-machine of the type known as a centrifugal reel, in which a set of beaters revolve at a high speed inside a cylindrical screen which revolves more slowly. The beaters throw the oxide against the screen and force it through the meshes, which do not need to be finer than 20 to the inch. Shaking screens are unsuitable, as they tend to make the oxide cohere in small balls. Revolving screens without beaters tend to form balls. and also to coat themselves with an impervious layer of oxide, and if brushes are used to clean the screen they only make this coating harder At intervals the coating drops off the screens and, with the balls, is discharged as rejections. This makes the operation of such screens very slow and wasteful.

Oxide of zinc is one of the most important ingredients of manufactured rubber, and its use is increasing very rapidly. Fortunately for the user it is remarkably constant in chemical composition and physical properties. The latter vary in the different grades, but the makers use every endeavor to keep them as nearly uniform as possible in each. Luckily, also for the user, it is rarely adulterated, and the adulterations are easily detected. The price, too, is stable, and any one who is misled by false ideas of economy into buying material as oxide of zinc at much less than the market price can hardly blame any one but himself if it proves unsatisfactory. If purchased from a reputable manufacturer and properly applied, it is certain to give satisfaction.

LITHOPONE: Lithopone is an amorphous white pigment made by mixing solutions of barium sulphide and zinc sulphate, which causes a transfer of the acids and produces an intimate mixture of zinc sulphide and barium sulphate. The properties of the mixture so formed are quite different from those of a mixture of the two dry salts. Barium sulphate has very little opacity, or hiding power, while zinc sulphide has a great deal. A mixture of the two dry has a hiding power intermediate between the two, and it varies almost directly with the proportion of zinc sulphide present. In properly made lithopone every particle of the barium sulphate appears to be coated with zinc sulphide and the opacity is much higher than that of a mixture of the dry salts in the same proportion.

The process of manufacture is complicated. The carefully purified solutions of the two salts are mixed; the crude lithopone filtered out, dried, heated to redness and plunged in water. The mixture of lithopone and water is then ground, filtered, dried and re-ground; it is then ready for packing. Every step of the process requires great care and careful regulation of conditions. If properly carried out it gives an excellent white pigment of great "strength," or hiding power. It is largely used in the manufacture of rubber goods, but the general opinion is that it does not give as strong, or resilient, a product as oxide of zinc. Care must be taken that no lead is present in the compound or it will darken seriously.

A good sample of lithopone should contain not less than 28 per cent. of zinc sulphide. It should be a good white, be smooth and free from coarse particles and have good hiding power. For use in rubber manufacture, however, probably the most useful test is to make up a small quantity of the compound.

A New Rule of Vulcanization.

By

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Strictly speaking, it is incorrect to use the term "a new law of Nature." Nature has no new laws. Her laws, so far as we can judge, have always existed and will always exist—unchangeable. By the term "a new law of Nature" we simply mean that from a series of observations of well-known facts, or of facts not before known, a law has been deduced which is new to us.

The known laws governing the chemical combination of rubber and sulphur during vulcanization have been deduced from well-known facts and are in no respect different from general laws governing chemical reactions. They may be briefly stated as follows:

1. *The combination is brought about by the influence of heat.*
2. *The velocity of the combination increases faster than the increase of temperature and decreases correspondingly with a decrease of temperature.*
3. *The vulcanizing effects of every vulcanizing temperature is the precise complement of every other vulcanizing temperature.*

Even a cursory glance at these laws enables one to see that they are general laws governing chemical reactions, and also that both the second and the third law suggest the existence of another.

While it is true that the majority of chemical reactions take place with development of heat and without external aid, there is a large number that require the aid of external energy (in the form of heat, light, pressure or electricity) to induce the reactions. The direct combination of a mixture of iron and sulphur in fine powder is a well-known example of a chemical reaction which requires the aid of heat (or pressure) in order that the combination may proceed at an appreciable rate, and seems in principle to be in no wise different from the manner in which the combination of rubber and sulphur is brought about.

As the rate of this combination increases or decreases with each increase or decrease of temperature, it is most natural to ask what this rate is. It is very strange that the rate or ratio seems to have been almost entirely unknown both to manufacturers and investigators, and the more so as a knowledge of it would be of great value in conducting vulcanizing operations, and would almost seem to be the foundation of a careful investigation of the subject of vulcanization.

To ascertain by actual experiment this ratio of increase or decrease, quite a large number of experiments have been made with the same compound and with samples of uniform thickness in nearly all of the well-known processes of vulcanizing with heat—in dry air—in dry air impregnated with sulphor vapor—in melted sulphur—in hot water without pressure—and in a metallic medium both with and without pressure. No experiments were made with the steam process or in hot water under pressure, as under the most favourable circumstances several minutes must be lost each time that samples are examined. The loss of so much time would be fatal to accuracy, as many of the tests did not occupy more than a few minutes, and some not more than a few seconds. For the processes which were used, it was necessary to devise apparatus which would permit an examination of samples without appreciable loss of time.

As the known laws governing vulcanization are identical with known chemical laws, it should be stated here that these investigations were suggested by a well-known law regarding the effect of an increase or a decrease of the velocity of chemical reactions in general. This law is stated so clearly by Professor Ostwald, one of the best known chemical authorities, that his statement of it is given in full.

" Innumerable substances between which chemical reactions can occur, can remain in contact with one another without our being able to detect such actions. The most appropriate interpretation of these facts is, that in all such cases the possible chemical reactions do, as a matter of fact, take place, but to such a small extent or with such slowness that they cannot be detected in a measurable time. The following shows that this view is quite compatible with the universal experience. By time measurements of the progress of many chemical reactions, *the approximate rule has been obtained that the velocity of chemical reactions is, on an average, doubled by a rise of* 10° *C.* (18° *F.*) *in the temperature.* That is to say, if a reaction at a given temperature requires, say, a quarter of an hour to reach a certain point, at a temperature of 10° C. (18° F.) higher it would require only 7½ minutes, and at one 10° C. (18° F.) lower 30 minutes. If the temperature is lowered 100° C. (180° F.), a 2^{10} equal to 1,024 times longer period is necessary, or, in our example, about 11 days. On descending further 50° C. (90° F.), or, on the whole, only the moderate amount of 150° C. (270° F.), it would be a year before the reaction had proceeded so far as it had done in a quarter of an hour at the higher temperature."

The experiments referred to were first made with a compound composed of 12 pounds dry fine Pará rubber, 6 pounds litharge, 6 pounds whiting and 6 ounces sulphur, which gives a proportion of about 3 per cent. of sulphur. As a result of the experiments, it was found that when the samples, containing 3 per cent. of sulphur, were submitted in the ordinary dry heat air process, approximately for the times given below, physical vulcanizing effects, as nearly identical as could be perceived on a most careful examination, were obtained when the submission was made at the temperature set opposite the times.

15	seconds	at	337° F.
23	,,	,,	326° F.
35	,,	,,	315° F.
1	minute	,,	304° F.
2	,,	,,	293° F.
3½	,,	,,	282° F.
7	,,	,,	271° F.
13	,,	,,	260° F.
26½	,,	,,	249° F.
53	,,	,,	238° F.
105	,,	,,	227° F.
210	,,	,,	216° F.
420	,,	,,	205° F.
840	,,	,,	194° F.

These results seem to establish the rule, *that for each increase in temperature of about 11° F. during the vulcanizing operation, the velocity of vulcanisation is doubled, and that for each decrease in temperature of about 11° F., the time required for vulcanization is doubled.*

As direct experiment, however carefully conducted, is more or less liable to error, and as it is somewhat difficult to judge exactly the physical degree of vulcanization of a rubber sample, the results above given may not be absolutely exact. But as they represent the average of a number of separate vulcanizations, they may be considered as accurate within the limits of experimental error.

It will be noticed that the temperatures given range only between 194° and 337°, and also that above 304° the ratio of increase is different. Below 194° the compound containing 3 per cent. of sulphur does not seem to vulcanize satisfactorily *by the air process.* But in other processes there is no trouble whatever in effecting vulcanizations in accordance with the foregoing rule down to 161°, which is the lowest temperature tried. Above 304° the rate of increase is changed for all the processes, probably because at temperatures a little above 304° there is a marked change in the physical constitution of sulphur, and possibly also because as experiments tend to show, the rubber compound used is proportionately a poorer conductor of heat at the higher temperatures.

This change begins considerably lower, but is apparently slight. As is well known, sulphur when heated above 250° gradually grows darker and becomes thicker, until from about 360° to about 430° it is so thick that it pours slowly from the vessel in which it is heated. These changes are believed to be changes in its molecular state and affect not only its physical constitution, but its chemical properties. That the law varies above 304° is to be expected, as the physical change in the constitution of the sulphur is attended with changes in its chemical properties.

Above 304° F. it is somewhat difficult to determine the ratio of increase. But a few experiments seem to indicate that a change of about 25° is required in order to double the velocity of vulcanization. Between 304°

and 400° the time required for doubling the velocity of vulcanization may be judged from the following table showing the approximate temperatures necessary to double the velocity:

325°	26	seconds.
350°	13	,,
375°	6	,,
400°	3	,,

As the time required at 400° was only 3 seconds, and as at considerably higher temperatures the time required is only the fraction of a second, it can be readily seen that it is very difficult to determine a ratio when such short periods of time are concerned.

Care was taken that the physical condition of the samples used for the experiments was as nearly identical as possible, as a variation in that condition would vary the time required for vulcanization. It was also necessary to use samples of the same age for comparison of results, as it was found that the longer they were left undisturbed at room temperature, the quicker they would vulcanize. Samples which had been kept nearly four months at that temperature required materially less time *for the same degree of physical vulcanization than when they were freshly prepared.*

This increasing ratio is substantially verified by recent experiments by Spence & Young (Zeits, Koll., July, 1912), who found that a mixing containing 10 per cent. of sulphur reached saturation after an exposure of 20 hours to a temperature of 135° C. (275° F.), and also after an exposure of 5 hours to a temperature of 155° C. (311° F.).

The result of these experiments naturally suggests the view not only that a properly compounded rubber vulcanizes at all temperatures, but that vulcanization commences immediately upon the compounding.

The preceding part of this paper was written in 1903. Shortly after that time experiments were made with a view of testing the truth of the proposition that vulcanization proceeds at all temperatures. Accordingly samples of Para rubber compounded with from five to seven per cent. of sulphur, and fifty per cent. of litharge were subjected to treatment at temperatures varying from 161° to 194° F. in a bath of metal which fuses at about 150° F. The results confirmed the general rule obtained in the preceding experiments, with the exception that the time required for doubling the velocity of combination was somewhat greater, for an increase of 11° F. in the temperature.

Samples of the same compound were then embedded in a ball of the same metal fused, which was then immediately plunged into cold water, with the result that any vulcanization resulting from such short exposure to so low a temperature was negligible. The ball containing the samples was then placed February 28th, 1904, in a room whose average temperature was estimated to be about 110° to 115° F. September 27th, or practically 7 months later, the samples were examined and were found to be thoroughly vulcanized. They are here to-day in a state of perfect preservation after the lapse of 8 years, and can be examined by any one who wishes to do so.

May 27th, 1904, samples of the same compound were embedded in a jar of flowers of sulphur, which was well corked, and exposed in the same room to the same temperature as in case of the last preceding experiment for 4 months. These samples were not fully vulcanized, but an examination to-day shows them to be well vulcanized, strong and elastic. The only inference to be drawn from this fact is that the vulcanization commenced at about 110° to 115° F. has been completed during the eight years during which they have been exposed to an ordinary room temperature.

In February, 1912, another series of experiments along the lines of those of 1904 were commenced. Similar samples of a similar rubber compound, and also samples of four different grades of rubber shoe compounds were placed in a ball of fusible metal, in a well corked jar of sulphur, and in two tight jars, one containing a mixture of one part by weight of sulphur with five parts litharge, and the other containing a mixture of equal parts by weight of sulphur, litharge and Green Seal French Zinc. In addition there were placed in each jar samples of pure fine Pará rubber, which had been peeled, as it were, from a crude biscuit, and which was therefore entirely free from compounds or mastication of any kind.

While the samples embedded in fusible metal were entirely free from the action of oxygen, they were also entirely free from any action of the other substances in which the other samples were embedded. The influence of those substances is very apparent even on a casual inspection of the samples.

Of the samples enclosed in fusible metal, the compound referred to is the only one that is properly vulcanized. All the others are vulcanized very perceptibly less than those embedded in sulphur, sulphur and litharge, or in sulphur, litharge and zinc.

All of the samples embedded in sulphur were vulcanized—the samples of second and third grade uppers being over-vulcanized.

The action of litharge and sulphur as compared with the action of sulphur alone, was very marked, the vulcanization of all the samples being carried much further than in the case of either of the other experiments.

The samples embedded in the mixture of sulphur, litharge and zinc were vulcanized to a greater degree than those embedded in sulphur, but less than those embedded in sulphur and litharge.

The most wonderful result of these experiments was the vulcanization of the pure Pará biscuit rubber. If, as is considered, vulcanization can only be effected by sulphur molecules S^2, it is obvious that at the temperature of 115° F. there is sufficient dissociation to produced in 7 months a fair degree of vulcanization in pure virgin rubber, which is entirely free from sulphur itself, but which has simply been embedded in sulphur. Still further, at ordinary room temperature, there must be some dissociation in order to complete in 8 years the sample which was deficient in vulcanization September 27th, 1904.

An analysis of the pure Pará rubber made after it had been embedded in sulphur six months, showed 0.49 per cent. of combined sulphur, the sample having been subjected to the acetone method for sixteen hours in order to remove every possible vestige of uncombined sulphur. If the rate of combination be the same for seven months as for six months, we should expect that there would be 0.5716 per cent. of sulphur in the sample embedded in sulphur for that period.

The result of the embedding of pure Pará rubber in the mixture of one part sulphur and five parts of litharge by weight, would seem to show that in this instance the litharge acted by promoting the dissociation of the sulphur molecule. Strictly speaking, it could not act as a carrier, as it was external to the rubber. The dissociated sulphur must then either of its own action, or by the action of the rubber, have penetrated the rubber and then combined with it.

Another important deduction to be made from the new law of vulcanization and the experiments made in accordance with it, is that the melting of sulphur has not the slightest effect in changing the rate of vulcanization, as whatever may be the time required to vulcanize a rubber compound at 227° F. it will vulcanize in one-half that time at 238° and in one-quarter the time at 249°.

Another deduction that can safely be made is that vulcanization of rubber properly compounded proceeds at all temperatures, whether high or low. At high temperatures the compound may be vulcanized in one second or less, and at low temperatures the vulcanization may proceed so slowly as to escape our attention.

Notes on Tension Tests of Rubber.

By

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United States Bureau of Standards.

The wonderful development in the rubber industry and the enormous demand for rubber products with their constantly multiplying and broadening fields of application, make it evident that the time is now ripe for the heartiest co-operation between manufacturers and consumers, with a view to establishing uniform methods of testing and, as far as possible, uniform specifications for goods intended for the same purpose. Uniformity of methods is absolutely essential to an intelligent comparison of the work of different laboratories, and a more general interest in the standardization of specifications and methods of testing would result in a substantial benefit not only to the reputable manufacturer and large consumer, but also to the public at large.

In testing materials in general, the refinement of the methods used should be determined in each case by the nature of the material tested, and in the speaker's opinion there is no reason why rubber should be an exception to the rule.

Now as regards testing machines and apparatus used in determining the physical properties of rubber, a most interesting field is presented, in which there is room for many improvements. However, when one considers the rather large and apparently unavoidable inherent variation in the physical properties of rubber, it seems that in the present state of our knowledge, uniformity of methods is more to be desired in testing than extreme accuracy and refinement in the matter of taking measurements. This of course is particularly true in the case of commercial or routine testing where the goods have been manufactured to meet the requirements of specifications. Unfortunately specifications are not always as definite as might be desired, nevertheless, the adoption by both parties concerned of uniform methods of testing, would remove the cause of numerous misunderstandings between manufacturer and consumer.

To discuss in a comprehensive way the various methods that have been proposed for testing the physical properties of rubber would require a more thorough knowledge of the subject than I possess, and far more time than is at my disposal to-day. There are, however, certain points in connection with methods and machines used in testing the tensile properties to which I should like to ask your attention, with the hope that sufficient interest may be aroused to bring out a discussion and an exchange of ideas and opinions on the subject.

In regard to the most desirable form of test piece, the ring and the straight specimen, each has its particular advantages, and considerable difference of opinion is being expressed as to the relative merits of the two. The method which is usually followed in preparing rings involves several distinct operations which, if carefully carried out, consume quite a good deal of time. On the other hand the straight specimen may be cut out by a single stroke of the die, the operation requiring only an instant. Rings, when accurately cut, undoubtedly show uniform results, but on account of the varying stress over the cross-section, this method does not give the true value for tensile strength. An analysis of the distribution of stress in a ring shows that near the breaking point the tension decreases at an approximately uniform rate from the inside to the outside surface. If this variation in stress were the same for all rubbers, the ring method might be accepted as giving a true relative measure of strength, but tension curves plotted for different rubber compounds show that this is not the case.

The ring lends itself very rapidly to the automatic measurement of elongation, and in this respect its advantage over the straight specimen is apparent. It may be noted, however, that since the strength of rubber is not the same in all directions, being greatest in the direction in which the sheet has been rolled, the ring gives a smaller ultimate elongation than is shown by a straight specimen. This difference in strength and elongation by the two methods is not always found, but the results of tests which I have made on twenty different compounds show a general tendency toward higher values for straight specimens, particularly in the case of high-grade compounds.

Objection to the straight test piece is often raised on the ground that specimens fail by tearing at or near the grips. This difficulty may be overcome by gradually increasing the width of the test piece at the ends, and by using a grip that will not bruise or injure the rubber by excessive pressure. A form of grip which the writer has found to be exceedingly convenient and perfectly satisfactory consists of a series of circular discs mounted eccentrically, and in such a way that each disc acts independently in pressing against the test piece. By this means the gripping pressure holding the specimen is automatically increased in proportion to the applied tension, and furthermore, the pressure is uniform over the entire width of the grip even in cases where the thickness of the rubber varies.

For measuring the applied load it would appear that preference is usually given to some form of dead weight or pendulum machine, the spring balance or dynamometer being often looked upon with disfavor.

It is the policy of the Bureau of Standards to encourage as much as possible the testing of rubber goods and for this reason our testing machines have been constructed with a view to the greatest simplicity consistent with a reasonable degree of accuracy. For determining tensile strength and elongation we use an ordinary twin spring dynamometer attached to the upper end of a metal column. This column is slotted to receive a rack which carries the movable grip and which may be operated either by hand or by motor, with stepped pulleys for different speeds to meet the requirements of experimental work.

It is necessary, of course, to provide means for cushioning or preventing the recoil of the springs when a specimen breaks. For this purpose we at first employed a dash pot, but later it was found more satisfactory to use a device which prevents recoil by holding the springs under the maximum tension. We realize that this method of measuring the load is in a way open to criticism, but at the same time we are gratified to find that after more than two years of continuous service the corrections for the dynamometers are so small as to be negligible, being well within the limits of variation of the materials tested. We have provided a set of weights with which the machines are calibrated from time to time, and should the dynamometers become inaccurate it will be a simple and very inexpensive matter to have the old springs replaced by new ones.

As already mentioned the measurement of elongation at rupture is a less simple matter in the case of a straight test piece than with a ring, the reason being that the rubber has a tendency to creep to a greater or less extent through the gripping surfaces, thus making it inaccurate to take measurements between fixed points on the grips. A little practice however enables one to observe the extension between gauge marks on the test piece with a fair degree of precision by pressing the end of a measuring scale gently against one of the marks and taking the scale reading just opposite the other mark as the specimen breaks. The dynamometer automatically registers the breaking load.

In my own experience the large amount of time consumed in testing the elasticity or what is commonly termed " set " or " recovery " after extension, has prompted me to devise means for expediting the work, with the result that a piece of apparatus has been constructed in which six specimens may be tested at once.

Of the tensile machines that I have had an opportunity to see in operation, or to study from illustrations, some appear to be rather better adapted to experimental or research work than to the requirements of routine testing. This is due partly to delicate or expensive construction, and also to the fact that more time is required in their operation than is desirable in ordinary routine work, for which, simplicity of construction, ease and rapidity of operation, would seem to be very desirable to say the least. For reasons already stated it would be difficult to obtain by autographic means, tension or hysteresis curves for straight test pieces. A rather slow but otherwise satisfactory method of securing curves may be carried out in the following way :

A narrow flexible scale either of paper or tracing cloth is attached to the test piece at the upper gauge mark by means of a small spring wire clip. From this scale one operator reads and announces the elongation at convenient intervals of 25 to 50 per cent., to a second operator who observes and records the corresponding tension. With a little practice this process becomes exceedingly simple and the points when plotted are found to give very smooth curves which clearly show the characteristics of different rubbers. Such curves offer a convenient means of studying the tensile properties of rubber when cut in different directions ; and when compared with similar curves obtained with ring specimens the influence of the form of test piece is clearly apparent. In testing twenty or more different compounds I have found that specimens cut longitudinally or in the direction in which the sheet has been rolled through the calender give curves that lie well above the corresponding curves for specimens cut in the opposite or transverse direction. Ring test pieces produce curves which lie below those for longitudinal specimens and which sometimes coincide very nearly with the curves for transverse specimens.

The tension test is generally considered to be the most satisfactory and most widely applicable test for soft rubber products. In its various modified forms it is used to determine the more important physical properties such as strength, ultimate elongation and elasticity of recovery after a definite extension or a definite load. The methods followed in making these determinations vary according to the judgment of different persons, and since the results obtained are thereby influenced to a marked extent, the importance of uniformity of methods is not open to question. Of the influences that appreciably affect the results of tests may be mentioned the following, which being familiar to those interested in rubber testing would make an interesting subject for open discussion :

1. Shape and size test pieces.
2. Method of preparing and measuring test pieces.
3. Design of grip.
4. Direction in which test pieces are cut (when straight specimens are used).
5. Temperature.
6. Previous stretching.
7. Time allowed after extension and release, before measuring set.
8. Speed at which rubber is stretched.

Reference has already been made to the influence of the form of test piece, and as regards the area of cross-section it appears that in the case of rubber, as in the case of other materials, there is a tendency for small test pieces to develop higher unit values for strength and ultimate elongation, than larger ones.

2. The preparation of test pieces and the measurement of cross-section is generally conceded to be of the greatest importance, and unless this part of the work is carefully and accurately performed, it is useless to expect uniform results to follow. When one considers that the width of ring as commonly used is only 4 mm it is seen that a very slight eccentricity of say ½ mm introduces an error of 12½ per cent. in strength. In the case of straight specimens this particular difficulty does not present itself, but here also it is necessary to make sure that the cutting edges of the die are parallel and sharp. The usual method of cutting straight specimens I believe, is to strike the die a sharp blow with a mallet, but when used in this way, unless the blow is well directed, there is a tendency for the die to drift to one side, thus producing a specimen whose cross-section is not rectangular. It would therefore seem worth while to employ mechanical means to insure that all specimens are cut alike. In our work we have found that an arbor press is perfectly satisfactory, and we use a piece of leather under the rubber to prevent injury to the cutting edges of the die.

For measuring the thickness, a spring micrometer is probably the most convenient and accurate instrument available.

3. The design of grip is of importance in that excessive local pressure often causes failure at that point. For this reason it would seem desirable

to use a form of grip which closes automatically as the tension is increased, and produces a uniform pressure across the end of the test piece.

4. As is generally known the tensile properties of a straight test piece are influenced by the direction in which it is cut and it is unfortunate that specifications sometimes fail to take this fact into consideration. For example, a common specification for water hose in this country limits the set after 300 per cent. extension, to 25 per cent. and a rubber compound used for such hose might show a set measured in the longitudinal and transverse directions of, say, 28 and 22 per cent., respectively. Unless this point were definitely covered therefore the hose might be accepted or rejected according to direction in which the test pieces were cut. The same is also true though to a less extent, in the case of tensile strength and ultimate elongation. This of course does not apply to ring specimens in which tension is exerted equally in all directions.

5. The influence of temperature on set, strength and ultimate elongation, though often disregarded, is undoubtedly great enough at times to justify consideration. When one considers that the temperature in a testing laboratory may easily vary twenty degrees or more between summer and winter it is not difficult to account for variations in results which might otherwise be overlooked.

6. The influence of previous stretching on strength and elongation is often so marked that it should be taken into consideration.

In testing for set and strength it is convenient to use the same test pieces for both determinations, but by so doing, the stretching which a specimen receives in connection with the measurement for set, has a tendency to increase not only its ultimate elongation but also its strength. This increase in strength appears to be more pronounced in high grade rubbers than in compounds of low quality. It is rather surprising that specifications do not always state the methods to be followed in this case.

7. There appears to be a marked difference in the methods followed in determining "set." Although it is well known that the recovery of rubber immediately after release is very rapid, it is not unusual to see specifications that require the set to be measured "at once" and the specimen remarked in preparation for a second stretch and measurement for set. Now since the straight specimen does not lend itself readily to the usual methods of taking autographic records and since it is very difficult to measure the set immediately after the release except by autographic means, much more uniform results could be secured by measuring the first set after a definite number of seconds, say fifteen or twenty, have been allowed to elapse.

A further objection to the practice of attempting to measure and remark the specimens immediately after release, is that a variation of only a few seconds in the time of remarking is sufficient to influence the second set very materially. So great is this influence in fact, that if the specified limits for set were insisted upon, material would often be accepted or rejected according to the quickness with which the operator was able to remark the test pieces after the first set.

8. A variation within reasonable limits of the speed at which rubber is stretched does not affect the strength and ultimate elongation to a very great extent, still its influence is generally considered to be sufficient to justify uniformity in the rate of stretching. Whether it

is more desirable to maintain a uniform speed, or to increase the load at a uniform rate, is a point on which there are differences of opinion. I believe that stretching at uniform speed is the method usually adopted in this country.

In conclusion I would state that my aim has been to deal principally with those points which are most essential to the development of uniform methods of testing, no attempt having been made to treat the general subject of physical testing in anything like an exhaustive manner.

Laboratory Organization in the Rubber Industry.

By

FREDERIC DANNERTH, Ph.D.,

Consulting Industrial Chemist.

There are certain persons to whom a manufacturer should tell the whole miserable truth of his failures—his lawyer, his chemist and himself. Above all he should be absolutely frank with himself. After he has congratulated himself upon the perfect manner in which his goods are being bought and his factory is being managed, he should stop for a moment for a close scrutiny of his plant.

The Consulting Chemist would very often like to question the manufacturer on this point, but he is prevented from doing so for obvious reasons.

Successful corporations of to-day have either a written or verbal arrangement with the managing directors, which is in effect :

1. To purchase the best raw materials for a given purpose at the lowest possible market price.
2. To criticize the manner in which the factory manager is making up these raw materials into saleable goods, and help him to attain perfection.
3. To help the salesman, when it is found that competitors are offering better quality for the same or for less money.
4. To deliver to the factory manager, heat, light and power at the lowest possible cost.

One corporation president who had risen to a realization of the importance of chemical consultation, recently opened a conversation thus :

" Our competitors have us skinned to death on water-tank packing ; we have been put out of the race with our air-brake hose ; our railroad steam-hose has rotted away in actual use. Do not waste any time on theoretical considerations and research work, but go right ahead and give us these three things. What we want is results, and you will have to earn your fee every day, for we cannot afford to gamble away one hundred dollars without getting the results we want."

As a matter of record it might be added that that particular man is still wanting those results. He has failed to realize that the science of Applied Chemistry was not created in an off hour, but is the product of many years of arduous labor and thought. From the day when " the compound man " was the chief chemist of the works, we have come to a point in the development of factory management where all chemical problems should first be presented to the Supervising Chemist, an official who occupies a position parallel with the Factory Manager and the Operating Engineer. In some cases he is permanently employed by the organization, while in other cases he devotes only a portion of his time to his duties at one particular factory.

The constant growth in efficiency of the rubber industry is largely the result of organization that insures the orderly use of every talent required. Occupying a very important place in such organization is the fullest use of a laboratory staff with trained chemists. It is the duty of this department to:

1. Investigate all new processes.
2. Constantly improve existing ones.
3. Correct and explain irregularities of current operations.
4. Invent new and useful processes.
5. Determine the value and exact composition of all raw materials.
6. Determine the value and composition of competitors' products.
7. Advise correctly on " specification goods."
8. Control different stages of many processes.

Hence if these constructive forces are to be used to the fullest, it must be through the creation of an organization that will cause every department in that organization to co-operate with the laboratory. To accomplish this I present for your consideration methods which are the result of careful study for many years in some of the largest manufacturing plants in America.

The Supervising Chemist is valuable to the firm in proportion to his perspective, his ability to see from afar the possibilities of some new proposition, whether it be a problem in purchasing, manufacturing or selling. Directly under him he has a corps of five first assistants who are in some cases designated as chief chemists. They are: The Engineering chemist, the Buyers' chemist, the Factory chemist, the Sales chemist, and the Research chemist.

The organization of the Laboratory Department includes:

1. Systematic abstracting of the important foreign and domestic journals and of the patents of the principal countries.

2. Forwarding copies of these abstracts weekly to all who can use them, with instructions to study them carefully and advise the Laboratory immediately of those which might be of value.

3. Thorough abstracting of the literature, in the case of new work, thus presenting all that has been published relating to the subject. Repetition of the work of others is thus saved, valuable suggestions are received and new lines of thought are opened.

4. A pamphlet library containing catalogs of machinery, structural material, scientific apparatus, etc., is kept up to date by correspondence with the manufacturers of these materials. This collection can be made far more valuable than regularly published books upon identical subjects.

5. All translating, abstracting and indexing should be in charge of one competent man, with assistants, if needed.

6. Superintendents should present to the supervising chemist, monthly reports embodying all ideas of their own, or their assistants, that might in any way warrant investigation. Through such a system thoroughly carried out, valuable suggestions can be obtained that might otherwise be lost. This plan will also stimulate closer thought and observation concerning all the details of manufacturing.

7. There should be (through proper connections) systematic prompt advices of all improvements in European practice that would be of value to the corporation.

8. The Laboratory should place at the disposal of the sales department, whenever this is necessary to demonstrate the value or quality of the company's products—a competent testing engineer, who can instruct the customer in the standard methods of conducting physical tests of manufactured rubber goods.

THE ENGINEERING CHEMIST receives instructions from the Operating Engineer (through the supervising chemist). His first and most important field of activity is the examination of materials used by the power plant. This includes:

1. Periodic analysis of the coal supply.
2. The control of combustion by flue-gas analysis.
3. The examination of lubricants.
4. The examination of the water used for boilers.
5. The examination of boiler deposits and boiler compounds.
6. Practical tests on the quality of paints and varnishes used in the works.

As a result of his contact with the power plant, the engineering chemist is in a position to provide the factory chemist with exact data on the wearing qualities of rubber goods used in the power plant. Such materials include steam-packing, transmission-belting, water-hose, conveyor-belting and washers of all sorts. He also keeps his eye on the various structural materials, metals and lumber brought into the factory, in which case he co-operates with the buyer's chemist.

THE BUYER'S CHEMIST receives instructions from the purchasing agent (through the supervising chemist). He is essentially an analyst, for he must determine the purity and the comparative commercial value of mineral drugs, organic fillers, reclaimed rubber, crude gum, textiles (sheeting, duck and yarn), and the various metals—which have been offered to the purchasing department. He must control all work relating to sampling and analysis, because so much depends upon prompt and accurate results. He must be able to devise special methods, and should endeavor to make his methods conform to those of the vendor so far as this is consistent with good work. He must record all physical tests made on rubber and textiles, and enter these with the chemical tests in a special folio kept for this purpose.

He devises for the purchasing departments rational specifications, so that it will be possible for the buyer to procure bids on a standard material which the vendors will be able to supply without an abnormal rise in price for the commodity.

THE FACTORY CHEMIST receives instructions from the factory manager (through the supervising chemist). He investigates problems which arise in the factory and endeavors, by simplifying operations, to reduce the cost of production. This may be attained by increasing the speed of machinery; by omitting unnecessary operations; or by eliminating waste. Before arriving at final conclusions regarding recipes for new compounds, he will, of course, have to make such examinations as " friction tests " on belting and hose ; pressure tests on fire-hose ; steaming tests on steam-hose and so forth.

Other problems which he must face from time to time are : the reclaiming of waste rubber ; the correction of defective cures on molded goods and steam-cured articles ; defective frictions on cotton-jacketed hose.

In addition to the actual manufacturing operations, he must follow up for the factory manager, the preparatory processes of washing and drying the crude gum ; compounding, mixing and calendering the stock. In his record book he enters all improvements made in any of these departments and devotes a separate page to each department. By thus entering the date on which the improvement or new method was installed, he will be in a position to give the factory manager complete data on the advantages gained by the step. He also makes such analyses as are necessary in the intermediate steps of some processes in order to insure proper control and a uniform product.

The " premature hardening " of steam-packing ; the " boot-legging " of belts ; the " blooming " of hose ; the " loose sleeve " effect on rubber covered rolls ; the " dead-friction " effect on cotton-jacketed hose ; the " uncurable " stamp gum ; the abnormal " swelling " of extract-tank packing—these are but a few of the innumerable defects which must from time to time be investigated by the factory chemist.

Another field of activity is the writing of recipes to meet certain specifications. The various government departments, municipalities and railroad companies have at present sharply defined specifications for the delivery of manufactured rubber goods, so that it has become necessary for contractors to exercise considerable caution in the making up of these goods. In such matters the factory chemist as a rule works in conjunction with the foreman of the compounding room.

THE SALES CHEMIST receives instructions from the sales manager (through the supervising chemist). To him are brought commercial rubber products put on the market by competing firms. His duty is to pick apart these products and determine the manner in which they were constructed, so that the desirable features of the sample can be duplicated if need be. He makes chemical analyses of these samples and carries out physical tests to determine in the laboratory their approximate value compared with similar products turned out by his employers. Thus he determines as far as possible the character of the textiles used and the particular fiber employed (whether it be cotton, flax, hemp, or ramie). He determines the " friction " value on belting and hose ; the strength and stretch value of the rubber lining in articles like fire-hose ; he also determines the tensile strength and other physical properties of such products as steam packings.

If the competitor's article is of inferior quality and is sold at a lower figure than the article made by his firm, he must give the sales manager information which will enable him to present these facts to the customer. The sales manager occasionally has turned back to him specimens of conveyor belting or transmission belting which have not stood the test of time. In such cases it is for the sales chemist to ascertain the exact conditions under which the belt has operated, so that he can determine whether or not the usage has been unexpectedly rough.

The Sales Chemist conducts the final physical and chemical tests on specification goods and places his " O. K." on all such orders before they are shipped.

THE RESEARCH CHEMIST receives instructions direct from the supervising chemist. The raw material for his researches is obtained to a considerable extent from his colleagues in addition to the problems which are mapped out for him by his superior. He should have at his disposal a well arranged and adequately equipped index to periodical literature and the patent literature of all countries. It is from these sources that many valuable suggestions are obtained, and it should not be forgotten that many very important suggestions for development work are obtained from sources entirely outside the rubber industry. Thus it sometimes happens that a chemical process which has been used in the leather industry, in the varnish industry, or even in some inorganic industry, has called forth in the mind of the chemist possibilities which would not appear at first thought. As the special chemist in charge of development work, he should be informed as to the latest advances in the way of machinery for all operations which involve chemical processes. Materials of construction for vulcanizing and reclaiming apparatus should also be given due attention by him. His duties comprise:

1. Investigation of cheaper raw materials.
2. Creation of new uses for products manufactured.
3. Examination of new products to determine their present and future value.
4. Promotion of increased efficiency.
5. Improvement of the quality of products manufactured.
6. Utilization of wastes.
7. Procuring more efficient structural material for apparatus.

Great care should be exercised in the selection of the Research Chemist, as he should embody all the varied talent and knowledge required in a wide field; and it is important here that only the very fit be retained, as the achievements of this department will very largely depend on two factors: (1) a highly efficient college-trained staff; (2) an organization that will, from every other department, invite periodic presentation of all questions worthy of research.

The collective talent of the research chemists should embrace:

1. Thorough scientific education in the principles of physics and chemistry.
2. The power to imagine new processes.
3. The power to discern the causes of various irregularities in manufacture.
4. The ability to submit these ideas to the test of experimental proof.
5. The habit of accurate observation.
6. The skill to deduce from such observation the correct conclusion.
7. The quality of discerning the one vital thing that counts amidst the maze of unessential generalities.
8. A knowledge of manufacturing that will make all conform to practical conditions.

"All these qualities, diligently applied," says Mr. William Ferguson in a recent communication, "are essential to the success of modern research."

The Research Chemist should have at his disposal a properly equipped research laboratory, with miniature mixing-mills, calenders, presses and vulcanizers, where work can be carried on in a test tube or on a manufacturing scale as occasion requires, in order to determine practical difficulties and costs. Together with the supervising chemist and the factory manager he forms the Research Committee which meets regularly to consider and advise upon all important investigations.

Questions presented to this department are settled: (1) by carrying out the experimental work upon a small scale; (2) abstracting the journal and patent literature bearing upon it; (3) increasing in size the experiments, as occasion warrants. Each investigation should be made by a man particularly fitted for the job, and this man made responsible, but he should constantly consult with other members of the staff whose knowledge or skill would be helpful. The progress made and the difficulties encountered should be presented to the Research Committee at its regular meetings so that it can advise when necessary. At the conclusion of each investigation: (1) a detailed report is made to the supervising chemist; (2) an exact estimate of the cost is made for each investigation. This will show the profit or loss in each particular case and will demonstrate the value of the research work as a whole.

THE SUPERVISING CHEMIST.

If a corporation has more than one laboratory, uniform methods of sampling, of chemical analysis and physical tests must be used throughout. The selection of standard methods and the complete written description of each should be under the immediate charge of the supervising chemist. Their accuracy should be first proved by analyzing mixtures of known composition. The various precautions to be observed should be prominently outlined at the end of each method, together with the experimental data, and where possible, equations showing the accuracy of the method. These methods should be issued to the different laboratories, and all chemists of the corporation required to strictly adhere to them. Without this, uniform methods and uniform results are impossible.

He assigns to his first assistants all analytical work which will aid the departments for Purchase, Manufacture, Sales and Engineering. He carefully investigates new methods of analysis and considers complaints presented by the sales department. He should call a weekly meeting of the chief chemists to discuss:

1. The company's standard methods of analysis.
2. Abstracts of promising analytical methods; and physical tests.
3. Patents of interest to the rubber industry.

A digest of this meeting should be forwarded to all the chemists of the company for comment and for filing. He has in his office a card index which contains condensed abstracts of all relevant articles from the chemical journals. One file is devoted to "Rubber-chemical" articles, while another contains indices to "Related Industries." Such an equipment facilitates considerably the investigation of any problem which is presented for his consideration. He should request of his chief chemists carefully worded reports of all work done and these should contain all results, whether favorable or otherwise. New methods (physical and chemical) suggested through the literature or through other chemists of the company, should be tried out, and if found to be an improvement they are incorporated in the Standard Methods of the company.

The policy of the supervising chemist should be to give his chief chemists a broad acquaintance with all the work of his department through the weekly meetings. All work should be systematically and independently checked by more exact or by different methods than those in daily use. Each man is held strictly responsible for the work entrusted to him, and he should be encouraged to become thoroughly familiar, through study and inquiry, with the theory and practical application of his work.

Foremen should, so far as possible, make simple tests to control processes under their charge, as they can often make a test in less time than it takes to send the sample to the Central Laboratory. Such work must, of course, be periodically checked by the laboratory. In order to estimate each man's capacity and to charge up the chemical work correctly a Laboratory Order Blank is used. These are numbered consecutively and a different color is used for each section (Factory, Buyer, Sales, etc.). One order accompanies each sample or request for laboratory investigation. It has a place to record:

Date on which the sample or request was received at Laboratory.

Actual number of hours spent on the investigation.

Date on which the results were handed in.

Results obtained; recommendations.

Signature of the chemist, the supervising chemist and the department for which the investigation was made.

The "History of the Case" can be conveniently typewritten on the back of the order. The completed order is filed in the laboratory, separate cases being used for each section. In order to prevent delay, due to loss of an "original" order, a carbon copy is made and this is filed in a case in its proper numerical order. No chemist undertakes any work without a Laboratory Order Blank of which a carbon copy has been filed. The "History of the Case" should be entered at least on the carbon copy. The laboratories of the several plants should be strictly subordinate to the supervising chemist. All standard methods of sampling and analysis must be standard methods of the company, so that superintendent and chemists should co-operate for their strict enforcement.

Salaries of the chemists should be standardized as far as possible and promotion made according to the kind of talent which the individual possesses. Thus it is found that some men are far better adapted for superintending factory work, while others are peculiarly fitted for research. The efficiency of the chemical department may be increased by:

1. Periodic visits to the different laboratories of the company by the supervising chemist, in order to see that the standard methods are being properly followed, and to enable him to compare the general efficiency of the plants.

2. Occasional visits of the supervising chemist to laboratories of other industries, in order to incorporate in his organization the favorable developments made by others.

3. Periodic general meetings of the chemists to promote cordial co-operation and to discuss specific subjects.

4. Periodic exchange of chemists between the different laboratories, to broaden the experience of the individual chemist.

5. Monthly reports by each laboratory of the company to the supervising chemist explaining all difficulties encountered in investigations and making suggestions for improvements in existing methods.

Laboratory buildings should be roomy, adequately lighted, well ventilated, and equipped with all apparatus required for accurate, rapid work. Unhealthful, dismal surroundings and crowded quarters interfere considerably with efficiency and progress in chemical work. Slovenly arrangement of notes and samples should not be tolerated by the head of the laboratory.

The Central Laboratory and office should have all important chemical and engineering periodicals in an easily accessible file, and should possess a permanent library of the best books on these subjects. All the laboratories should be in the same building, so that the library may be easily reached and the individual chemists may have consultations. In the case of a corporation with plants in different cities, the Central Laboratory should be connected with one of the large plants, so that the mechanics will be available for construction work in the laboratory. Such a location makes it possible for the chemists to ask advice of the foremen and superintendents. Certain rules, such as those given below, might well be posted in the laboratories :

1. The accuracy of balances, weights and measuring apparatus, thermometers, and hydrometers, must not be taken for granted. They must be checked for accuracy by comparison with standards of known accuracy as often as required.
2. All standard solutions must be checked by the head of this laboratory or one of the chief chemists.
3. All important determinations must be made in duplicate.
4. All clerical work and calculations must be checked.
5. Systems of weighing and manipulation, devised to prevent errors, should be employed, and adhered to even in the simplest determinations.

The form of organization, just described, must never take the semblance of dull routine. The personnel must be of the highest type and all necessary plans must be carried out with enthusiasm and thoroughness. The interest in the work can be decidedly sharpened by having the chemist come into personal touch with the department for which his work is being carried out.

The laboratory department should lead the way so strikingly, that its methods are never justly censured. It should, by precept and example, be an exponent of the profession of chemistry.

The plan just outlined provides for a chemical department with one supervising chemist and five first assistants, but it will readily be seen that the functions of these chemists must in certain cases be embodied in a smaller number of men. This should, however, not interfere with the sub-division of work, and great care should be exercised, in keeping records as to the time spent on any investigation and the results arrived at. For this purpose an adequate system of Laboratory Order Blanks should be installed in the manner indicated. (See " Supervising Chemist.") The supervising chemist must interview his assistants at least once each week and obtain from them written reports of progress.

In one case which was brought to the speaker's notice, the corporation professed that such a corps of men could not be maintained, as the cost would be prohibitive, yet that same factory was operated in such a manner that every three workmen were doing work which could, without any undue training, be performed by two men. That corporation was keeping down its production by employing unproductive men in quantity, at a minimum wage of $10 per week. A large part of the success of chemical supervision will, of course, depend on the use made of the laboratory by the factory manager, the buyer and the sales manager. Parkhurst has called attention to the need for showing clearly the line of authority and the responsibility of each individual. The duties of each person must be determined and the positions should be filled by men who have had an adequate training in chemistry. The factory manager should be so sure of his ground that he will not have to fear anything from an inspection of the factory by the supervising chemist; on the contrary, he should draw the chemist into his confidence and call his attention to " weak spots " in the chemical processes, so that he may benefit by his suggestions. This point is fully covered by that basic principle of factory management: " Each and every employe shall be supplied with written instructions describing fully his duties and responsibilities." Important details of a process are sometimes forgotten, because an employe who was at one time given oral directions, has died or has been transferred to another department.

In the laboratory, as in all other departments, remarks such as " RUSH," etc., should be omitted from an order. In their place should be put a definite date on which a report is desired. This makes it impossible for any work to be postponed as a matter of convenience or in some other weak plea. If a new material is offered to the purchasing department, it is important to know at an early date whether it is desirable or not, and the same remark holds good for material which is tested previous to shipping, by the sales chemist.

Thus it is seen that scientific management includes not only the factory, but the purchasing and selling departments as well. It resolves itself into—buying the best material of a given grade at the lowest possible price and the sale of a finished product of a given quality at the lowest possible price. To accomplish this end, our most progressive manufacturers have drawn to their aid the services of one or more men exercising the above functions.

Railroad Air Brake Hose.

BY

J. S. SHEAFE,

Engineer of Tests, Illinois Central Railroad.

The requirements of air brake hose are prescribed by the Master Car Builders' Association so that hose applied to all railroad equipment shall be uniform and up to a certain standard. But air brake hose, as now being manufactured, does not comply with the M. C. B. requirements in other than the physical tests.

For instance, M. C. B. specifications prohibit the use of rubber substitutes. Pure rubber certainly cannot be used at the price paid.

Neither can a fair grade of rubber. In calling for a "hand made tube composed of three calenders of rubber," the requirement is not met as hand made tubes and those consisting of three calenders of rubber are only made on special order and at an advance in price. The great bulk of air hose tubes today are single calender and machine made, or "squirted."

In calling for swelled ends more difficulty is met with in the manufacture and a less perfect hose results. The inside and outside diameters should be the same throughout the entire length of the hose.

Air brake hose today is poorer than formerly and both the railroads and manufacturers may be blamed; the former for continually hammering down the price asked for an honest article, and the latter for consenting to attempt the manufacture of an article at a price below that which they know can be fairly met. The quality of air hose of necessity must be improved and both the manufacturer and consumer must work together, making concessions where necessary, for the ultimate mutual good.

Air hose today is sold as low as 30 cents and as high as 50 cents per foot, a difference of 66 per cent. How much can be expected of air hose costing the minimum?

This is a splendid illustration of false economy as the extra number of poor hose lengths necessarily purchased overbalances the increased cost of better hose; this too, when only the relative service is considered. In addition, and directly attributable to cost, should be considered the labor of collecting, shipping, dismounting and fitting up, each of which would not be necessary so frequently to be done with better hose.

The M. C. B. Association allow a cap from 1/16 inch to ⅛ inch in thickness. A cap of 1/16 inch is better than one of ⅛ inch thickness. Even less than 1/16 inch would be preferable. If the cap is made only thick enough to protect the exposed end of the fabric during the process of vulcanization the clamp used will not overlap the fabric, thus increasing the possibility of hose pulling off of nipple.

Some claim has been made that air hose is quite generally porous. The percentage of porous hose, i. e., those pieces which have leaked and which, on examination, have no evident defect, may be fairly placed at not over 5 per cent. This appears to be a reasonable maximum.

The cause of the largest number of failures appears to be the result of outside injury. Such failures are entirely apart from any inherent weakness of the hose. The "Railway Age Gazette" of April 19, 1912, places the number of such failures at from 65 to 70 per cent. There is good evidence at hand in hose shops to corroborate this statement.

The use of power machines for inserting nipples and couplings into air hose should be discouraged. The inner tube will be cut if there is any roughness to the shank of the nipple or coupling, or if they are out of line in entering. Mounting can be almost as rapidly done by hand and with the certainty that no danger to the inner tube results.

One of the M. C. B. requirements is that the friction between layers of duck shall be such that a 20-pound weight attached to the free end shall, in ten minutes, unwind less than 8 inches, the section being 1 inch in width. Just how far a "high friction" hose is advantageous is a question. Tests made by a large railroad, wherein a machine was used for kinking the hose while under pressure, resulted in a better showing for hose made with little friction than that made to meet the M. C. B. requirement. While this may not prove anything it at least opens up a very interesting point in the subject of air hose. In the same tests, hose with poor friction gave better results in the bruise test. This bruise test was made by fastening the hose, under air pressure, to an anvil, and causing a 20-pound weight to fall upon it at the nipple end.

There can be no doubt of the deterioration of the average air hose within six months of manufacture. The making of hose to wear well is quite the important part of the manufacturer's problem. No matter how good the hose is at the start if it becomes useless after a few months, the loss to the consumer is immense.

Some rubber manufacturers say that a good stretch test of the tube and cover, combined with a tensile strength requirement, will do more than any other one thing to increase the life of the hose. Tensile strength proposed by these manufacturers varies from 650 to 1,200 lbs. per square inch. As hose in service does not stretch the 200 or 300 per cent., is the stretch test practical ? A rubber band will stretch many hundred per cent. and yet its deterioration is rapid.

It would appear that the rubber manufacturers could make a more lasting hose by compounding a tube and cover with just as much or as little flexibility as would be necessary for long life. The minimum amount of flexibility would have to be sufficient to allow bending, without kinking, in coupling up.

It would also appear that the amount of damage caused by pulling hose apart, without uncoupling, is exaggerated. It is probably the universal practice in yards for switchmen and trainmen to thus neglect uncoupling. If an observation will be made in a yard, it will be found, on examining hose so treated, that failure is evident in none of them, provided the coupling has not been jammed and that a wedge has not been made use of to take up leakage in the gasket. As proof of this we have the strength of our air hose, versus the resiliency of the gaskets ; the former is much greater.

In considering defective hose, and from which follows a leaky train line blamed on the hose, leaky angle cocks, nipples and couplings must not be lost sight of. They contribute their fair share of the extra burden on the air pump. A more careful inspection of air hose by car inspectors may save damage, as a hose ready to fail may be sometimes removed in time to avoid failures.

Some attention has been given to the question of making air hose with one or more ply woven. This appears likely to be the best hose of the future.

If the manufacturers will produce a hose with an inner tube hard enough to protect itself from the nipple, and a cover hard enough to protect itself from the clamp, both of ability to withstand the action of time and weather for approximately 36 months, and will demand a price commensurate with the ingredients entering into the manufacture, the whole situation will be greatly improved.

Navy Specifications.

By

E. S. LAND, NAVAL CONSTRUCTOR, U.S.N.

In purchasing material of all kinds it is necessary, particularly where competitive bids are invited, to prepare certain data to enable the manufacturers to submit an intelligent bid. Such data are usually termed specifications. To prepare satisfactory specifications is an art in itself—one that is the subject of keen discussion, wide divergence of opinion and considerable abuse.

In order to cover the ground properly, great care and infinite pains as to details are required, yet the limits must be broad enough to admit of the widest competition available. Considerable care must be exercised not to incorporate clauses which would exclude certain manufacturers or prejudice them against competing; yet at the same time it is essential to incorporate certain clauses which indicate in sufficient detail the quality of the material or the design of the apparatus being purchased.

To avoid the incorporation of proprietary clauses, and clauses calling for patented articles, needs a nicety of judgment difficult to find.

One is apt to hear the statement that "specifications are all rot," that they increase the cost unnecessarily, that they are made only to be "skinned," that one should buy an article because one knows by experience that it is satisfactory for the purpose intended, without going to the infinitesimal and useless detail of specifications. It is freely acknowledged that there is some truth in each of the statements, but that they are basically erroneous as far as Government business is concerned is stoutly maintained.

A private concern can, and a great many of them do, purchase material without specifications of any kind, but they are at liberty to choose the manufacturer who furnishes such material, and if the material furnished proves defective they are at liberty to cease dealing with said manufacturer; not so the Government, which is required by law to purchase material of the lowest bidder offering satisfactory material; and in case the material proves defective there is a certain amount of redress in attempting to eliminate the manufacturer of inferior material when future bids are being considered. Theoretically the Government is on the same plane in this respect as the private concern; practically this is far from being true. It is exceedingly difficult to eliminate unsatisfactory dealers from competition for Government business; only after the most flagrant abuse of the Government's confidence is it practicable to eliminate such dealers, and even if once eliminated the elimination only obtains for a short period of time.

Government business is more or less successfully hedged in by politics, and by the great American spread-eagle spirit sometimes embodied in the expression "the Government owes me a living"; and more often by the underlying statement, "Well, I'm a tax-payer and support the Government; therefore I've such and such rights." When you run across such statements as these there is no answer.

If it were possible to deal only with reputable, reliable concerns most of the difficulties would be solved, but it is a recognized fact that one is up against all gradations of dealers, from the man whose material is *par excellence* to the man who wishes to furnish you with something "just as good"; from the man whose trade name is a guarantee of quality to the jobber who intends to give you the very poorest material he thinks there is any chance of having accepted; from the man whose establishment represents years of business skill, sagacity and experience, to the man who "carries his office in his hat."

In dealing with all kinds of people it is absolutely essential to safeguard the interests of the Government by covering material desired with detailed specifications carefully prepared and as adequate as practicable.

To prepare these specifications it is frequently necessary to consult a number of manufacturers whose life-long experience enables them to adequately cover the ground; it is manifestly impossible for any person to have an intimate knowledge of the manufacture of all material used by the Department.

Department officials have always received the greatest consideration and assistance from manufacturers in the preparation of suitable specifications for naval purposes. With this information and with a knowledge of naval requirements, the problem then becomes a matter of digesting the information available and producing therefrom a broad statement of the material desired for the specific purpose, together with sufficient details to enable the manufacturer to obtain reasonable understanding of what is desired.

It frequently happens that the limits at first evolved are too narrow for adequate competition; revision is then necessary, as it is the Department's desire to approach commercial standards as closely as possible.

Essential Features.

1. The title should state in general terms the type of the article and purpose for which it is intended, viz.: "Specifications for cast iron porcelain lined lavatories for ships' use." "Specifications for metal uniform case locks." "Specifications for ship's electric ranges."

2. If a revised specification, the title should state the specifications which it supersedes, viz.: Superseding specifications 3-C-1," issued August 8, 1901.

3. The first paragraph of specifications should state in general terms the type, character and number of parts.

4. The second paragraph should give general dimensions and capacities.

5. The following paragraph should give detailed description of parts. If an article is composed of several complete units which when combined make a complete whole, the separate units should be subheaded and each described in detail. For examples see "Specifications 57S2, Combination Sterilizing Outfits for Operating Rooms; sub-heads:

Water Sterilizers, Bowl and Utensil Sterilizer, Instrument Sterilizer, Dressing Sterilizer, Valves and Fittings," etc.; also "Specifications 26-C-1, Chairs for the United States Navy."

6. Requirements for tests, if any are necessary.

7. Tolerances allowed, and terms for acceptance if material does not meet the specifications in certain respects.

8. Instructions as to packing or shipment, where applicable.

9. A statement to the effect that questions as to interpretation of the specifications should be referred to the Yard, station, or place where the inspecting officer for the material in question is located.

10. Paragraph stating where specifications can be obtained.

11. References—In this connection abbreviate, i. e.:

"Con. Off. New York, 2119 UX Apr. 15, 1911," signifies Construction Officer, Navy Yard, New York, letter number 2119 UX, dated April 15, 1911.

12. When illustrations are considered necessary the tracings for reproduction should be made on sheets 5 inches x 8 inches, so that they may be reproduced that size without reducing. If the article to be shown is too complicated or on account of the arrangements to be shown could not be drawn clearly on the above size sheet, it should be drawn so that it can be reduced to that size for printing and yet have all lines and figures readily readable. Tabulations, titles and other information which can be embodied in the text of the specifications should be omitted from such tracings. The ink should be black and the lines drawn slightly heavier than ordinary in order that a clear reproduction may result. If impracticable to show all of the illustrations desired on one sheet 5 inches x 8 inches, other parts required should be arranged so as to appear on one or more other sheets of the same size. The drawing itself should not go beyond the limits of ½ inch from the edge of the 5 inch x 8 inch sheet.

Some Observations on the Testing of Steam and Air-Brake Hose Used on Railway Locomotives and Cars.

By

G. C. BISHOP.

(*Superintendent, Motive Power, of the Long Island Railroad Co.*).

We will first consider air-brake hose of 1⅛ inch x 22 inches and 1⅜ inch x 22 inches. On a certain sample of hose the specification called for (1) a bursting pressure of 500 pounds per square inch exerted for 10 minutes; (2) at a pressure of about 200 pounds per square inch, the hose must not expand in diameter more than one-quarter inch or change in length more than one-quarter inch; (3) a friction test: with a weight of

DATA SHEET "A."

PERFORMANCE 1⅛ INCH AIR HOSE, PASSENGER.

	Item.	A	B	C	D	E	F	G	H	Totals
Cause of failure, per cent. Average life in months.	Damaged in service	410	174	28	46	23	109	21	5	781
	Per cent. of total	24.2	29.0	24.6	41.8	38.3	50.2	22.6	41.7	26.9
	Average life, months	14.8	14.0	9.9	10.5	7.68	5	11	27	12.62
	Bursted in service	441	107	19	34	12	47	26	2	6.85
	Per cent. of total	26.0	17.8	16.7	31	20.0	21.6	28	16.65	23.6
	Average life, months	15.5	16.43	9.68	14.1	15.75	7.53	14.24	27	15.1
	Deteriorated	574	251	23	51	23	36	29	3	9.68
	Per cent of total	33.8	41.8	20.2	46.4	38.3	16.6	31.2	25	33.4
	Average life, months	19.4	19.7	9.65	31.6	25.4	16.54	18.85	27	19.0
	Other causes	270	98	44	10	2	25	17	2	4.62
	Per cent. of total	15.9	16.35	38.6	9.1	3.33	11.5	18.3	16.65	15.9
	Average life, months	15.6	16.8	9.52	11.8	19	6.96	12.75	2.55	1421
Total failures		1695	600	114	110	60	217	93	12	2896
Amount purchased in 3 years		7500	2100	500	1900	500	2800	1000	300	16600
Per cent. failed in 1 year		22.6	28.5	22.8	5.8	12	7.75	9.3	—	17.75
Average life		16.05	17.5	10.26	16.5	16.11	8.3	17.73	25	17.5
Amount inspected		7700	2100	500	1900	500	4000	1000	300	18090
Amount accepted		7500	2100	500	1900	500	2800	1000	300	16600
Amount rejected		200	—	—	—	—	1200	—	—	1400
Per cent. rejected		2.6	—	—	—	—	30	—	—	7.85
Average friction in 10 minutes at 25 lbs.		1.28″	.99″	1.167″	1.15″	1.38″	2.07″	1.23″	4″	1.29
Outer tube stretch		.199″	.204″	.142″	.194″	.135″	.208″	.20″	.125″	.1952
Inner tube stretch		.216″	.142″	.142″	.163″	.225″	.227″	.225″	.125″	.1955

25 pounds suspended from the end the separation must be uniform and regular, and the average speed must not exceed six inches in 10 minutes; (4) a stretch test: between marks two inches apart on a piece one-half inch wide, stretched quickly until the marks are 10 inches apart, released, then re-marked as at first and again stretched to 10 inches, the specimen must remain 10 minutes without breaking; and (5) after release the distance between the marks must not show a permanent set of more than one-quarter inch.

The 1⅛ inch x 22 inch air hose is used with an automatic connector of the general appearance shown below.

Data sheet "A" shows the number of hose lengths removed for all causes during the year from November, 1911, to November, 1912, this being classified under (1) the general causes for removal, and (2) the life. The total number of hose purchased of each make for a period of three years is also shown as an indication of the proportion of the different makes of hose in service. The different makes of hose are designated by the letters "A" to "H" inclusive.

It will be noticed that a large proportion of the hose is removed because of being damaged in service. This is largely due to the automatic connector, which increased the chaffing and cutting of hose.

Little can be learned from makes "B" and "H," as they represent purchases made three years ago, and only the oldest hose was removed in the period covered by our data. It is interesting, however, to note that the removals of "B" hose represent a comparatively high percentage of the amount purchased, and the high *average life* checks with the high *average characteristics* shown by the tests.

"F" hose, it will be noted, shows a large percentage of rejections, and from our inspection of the results of the tests the reason is apparent. The friction is below the average, and the stretch just passes. Although the bursting tests are not shown, the rejections are numerous, and the lots accepted were just within the requirements. This hose was all purchased in the year 1912.

"A" shows a fair life, and the results of the tests closely approach the general average.

"C" represents one purchase only, but the test results were uniform and very good; the explanation of the low life is that the hose was soft and a considerable quantity failed shortly after application, due to inability to properly clamp the hose around the nipples.

"D" shows a good life, even though the percentage of damaged hose is high, the removals are small, and the test results are better than the general average.

"G" has a good average life, probably due partly to the small percentage of hose damaged in service. The average result of the test is good, with the exception that the stretch of the outer tube is above the average.

1⅜ x 22-inch air hose is used on freight cars only, and is not subject to the peculiarities of the auto hose connector as is the case with the 1⅛ x 22 inches.

Data sheet "B" shows number of this hose removed for all causes during the year from November, 1911, to November, 1912, this being classified in the same manner as the 1⅛ inch x 22-inch air hose.

Makes "E" and "H" represent small purchases made about three years ago, and may be eliminated from a study of the data, as our records cover only the hose having probably the longest life.

DATA SHEET "B."

PERFORMANCE 1⅛-INCH AIR HOSE, FREIGHT.

	Item.	A	B	C	D	E	F	G	H	Totals
Cause of failure, per cent. Average life in months.	Damaged in service	28	60	6	1	7	7	—	5	112
	Per cent. of total	13	17	28.6	4.06	13.4	22.6	—	5.9	14.25
	Average life, months	10.25	17.55	5.34	12	21.2	9.14	—	35.0	14.4
	Burst in service	128	193	7	14	29	14	2	46	43.3
	Per cent. of total	59.3	54.7	33.3	58.1	55.6	45.2	40	54	55
	Average life, months	21.45	22.4	12.05	25.43	23.3	11.15	16.5	26.9	21.02
	Deteriorated	53	87	3	7	15	6	2	34	205
	Per cent. of total	23.1	24.7	14.2	29.1	28.8	19.3	40	40	26.7
	Average life, months	21.8	20.8	12.33	27.5	24.3	17.3	27	26.4	22.3
	Other causes	7	14	5	2	1	4	1	—	34
	Per cent. of total	3.24	3.97	23.8	8.12	1.92	12.9	20	—	4.33
	Average life, months	11	17.35	9.8	14.5	24	12	6	—	14
Total failures		216	352	21	24	52	31	5	85	786
Amount purchased in 3 years		3900	5500	500	500	500	2200	—	800	13900
Per cent. failed in 1 year		5.6	6.4	4.2	4.8	10.4	1.41	—	10.6	5.65
Average life		20.7	22.3	12.0	26.9	23.3	11.9	16.2	27.2	21.0
Amount inspected		3900	5500	500	500	500	3500	—	800	15200
Amount accepted		3900	5500	500	500	500	2200	—	800	13900
Amount rejected		—	—	—	—	—	1300	—	—	1300
Per cent. rejected		—	—	—	—	—	37.2	—	—	8.55
Average friction in 10 minutes at 25 lbs.		1.57″	.835	2.5″	.48″	1.5″	1.68″	—	2.13″	1.265
Outer tube stretch		.178″	.165″	.083″	.208″	.23″	.23″	—	.234″	.1505
Inner tube stretch		.194″	.185″	.073″	.146″	.15″	.23″	—	.190″	.1573

The same criticism which applied to make "F" of the 1⅛-inch x 22-inch air hose applies in every particular to the 1⅜-inch x 22-inch air hose.

"G" may also be eliminated, as none was purchased during the three-year period and only five failures are recorded.

"A" and "B" represent a considerable number of lengths with sufficient failures to afford proper comparison. The results of tests indicate that "B" is the better hose, and this is confirmed by increased life.

"C" hose has a friction inferior to the average and the life is low.

"D" has the highest average life, and the tests show a good inner tube and the best friction.

From a study of the relation of the service of air hose to results obtained from tests of sample pieces, we draw the following conclusions:

1st—To prolong the life of hose from a possible bursting failure a good friction is necessary.

2nd—The quality of the inner tube as determined by the stretch test gives an indication of the probable life of the hose before it fails due to deterioration.

3rd—That the outer tube merely serves as a protective coating, and the chief requirement is that it remain intact.

Steam-Heat Hose.

The steam hose from which the following data are compiled was of one size, 1⅜ inches x 24 inches, used on passenger cars, locomotives and tenders. All this is used with an automatic connector, illustrated under the discussion of air hose. The construction and shape of this hose are shown annexed.

The essential points of the specification under which this hose is purchased are that the sample piece is to be tested as follows: A piece of the inner tube one-half inch wide cut circumferentially with the grip ends one inch wide, must show an elongation to not less than six inches before breaking (between two marks that have been placed two inches apart). The ultimate tensile strength of this piece must be not less than 600 lbs. per square inch. The friction of a section one inch wide must be such that the duck will not start to unwind with a pull of less than 20 lbs. The remainder of the sample is then placed in a closed vessel, known as a digester, and subjected to dry saturated steam at a pressure of 45 lbs. per square inch for a period of 48 hours. The hose is removed from the digester and sufficient time allowed for it to cool naturally. The tests are then repeated, and the stretch test must not show a deterioration of more than 20 per cent., while the tensile strength and friction test must not show a deterioration of more than 30 per cent.

Further, an inspection of the hose after its removal from the digester must not disclose any swelling in diameter or increase in thickness of the various parts, and there must no be indication of blisters or loosening of the inner tube.

Data sheet "C" shows number of this hose removed during the year from November, 1911, to November, 1912. The data show: (1) the general causes for removal, and (2) average life of hose. The total number of hose of each make purchased is shown as an indication of the proportion of the different makes in service. Further, a comparison is made between service life of hose purchased from November 1, 1910, to November 1, 1912, under the specification described and hose purchased the previous two years without specifications.

DATA SHEET " C."

PERFORMANCE 1⅜-INCH X 24-INCH COR. STEAM HOSE.

	Item.	A	B	C	D	E	F	G	H	Totals
Cause of failure, per cent. Average life in months.	Damaged in service	—	—	8	—	7	—	1	—	16
	Per cent. of total	—	—	2.43	—	4.02	—	33.3	—	3.08
	Average life, months	—	—	12.3	—	6.86	—	15	—	11.25
	Burst in service	—	—	168	—	102	—	1	—	271
	Per cent. of total	—	—	51.4	—	58.5	—	33.3	—	53.7
	Average life, months	—	—	12.74	—	67.5	—	15	—	10.26
	Deteriorated	—	—	111	—	64	—	1	—	176
	Per cent. of total	—	—	34	—	36.8	—	33.3	—	35.0
	Average life, months	—	—	13.84	—	7.97	—	27	—	12.02
	Other causes	—	—	40	—	1	—	—	—	41
	Per cent. of total	—	—	12.22	—	0.58	—	—	—	8.15
	Average life, months	—	—	12.53	—	6	—	—	—	12.4
Total failures -		—	—	327	—	174	—	3	—	504
Amount purchased in 2 years		400†	—	400	—	800	—	400	—	1600
Per cent. failed in 1 year		—	—	82	—	21.5	—	.75	—	31.5
Average life		—	—	13.1	—	7.43	—	10.0	—	11.95
Amount inspected		—	—	400	—	1400	—	400	—	2200
Amount accepted		—	—	400	—	800	—	400	—	1600
Amount rejected		—	—	—	—	600	—	—	—	600
Per cent. rejected		—	—	—	—	43.0	—	—	—	27.0
Average friction before and after digester test		—	—	25 lbs.	—	23.7 lbs.	—	27.3 lbs.	—	24.3lbs
		—	—	17.5 lbs.	—	16.6 lbs.	—	22.5 lbs.	—	18.2 lbs.
Inner tube elongation from 2 inches before and after digester test		—	—	9″	—	8.2″	—	8.5″	—	8.45″
		—	—	6.5″	—	7.3″	—	6.3″	—	6.8″

Average No. steam-heated cars operated in last two years	404
Average No. steam-heated cars operated in 2 years previous to above	387
Specification hose purchased in last 2 years	2000
Non-specification hose purchased in 2 years previous	3300
Specification hose used per car year	2.5
Non-specification hose used per car year	4.3

†This hose considered only as to total consumption in last two years. No records as to tests.

Make " A " represents hose purchased about November 1, 1910, under specification, but there is no record of tests ; so this hose is not considered except in the comparison with the non-specification hose.

" C " has a high life, and the tests show results well within the requirements.

" E " hose has a fairly low life, and the tests show the quality of the hose to be the poorest of the makes considered.

" G " hose shows an average life of only ten months, but it will be interesting to note that the most of this hose was placed in service in November, 1911, and the record of failures covers only three pieces. This is but $\frac{3}{4}$ of 1 per cent. of the hose purchased of this make. The indications are that a high average life may be expected from this hose when a sufficient number of lengths have been removed to give accurate data. The quality of the hose as shown by the tests would confirm this belief.

A study of the information collected shows :

1st—The desirability of purchasing hose under proper specification, as the consumption has dropped from 4.3 pieces of non-specification hose per car per year to 2.5 pieces of specification hose.

2nd—That the service life of steam hose is largely dependent on the quality of the friction between the layers of duck, as indicated by tests made after removal of test hose from the digester.

3rd—Tests made of this hose before being subjected to steam pressure do not give much information as to the suitability of the hose for the required service. This indicates that a satisfactory specification need not include this steam test. It is thought, however, that better steam hose can be procured by raising the friction test and stretch test. A specification now being tried requires that the properties before and after the digester test be the same.

A Brief History of Fire Hose Specifications in the United States.

By

E. A. BARRIER,

Factory Mutuals Laboratory.

This paper is not presented as a brief in defence of the present Underwriter Hose Specifications, but is intended to relate the more important events which have led to their development.

The statement, still occasionally heard, that fire hose is installed principally for fire insurance inspectors to look at, was evidently the standard used by a large number of manufacturers previous to 1890. The quality of hose, especially that for private equipments in those days was truly remarkable. It was a matter of common occurrence for length after length to burst at pressures well under 100 pounds and if the rubber lining stayed soft and pliable for two years, the purchaser could consider himself lucky. Frequently the backing would fail, allowing the lining to separate from the fabric and occasionally the lining would be ripped out by the water and be washed along with the stream, plugging the nozzle. It is true that in many cases the price of the hose was so low that a good grade could not have been expected, but this does not alter the fact that the situation was a serious one and badly in need of improvement.

Steps in this direction were first undertaken by Mr. John R. Freeman, then connected with the Inspection Department of the Factory Mutual Fire Insurance Companies, and now one of the foremost hydraulic engineers in the country, although still connected with the Mutual Companies in the capacity of president of several of the individual companies. Mr. Freeman had previously, in 1888, conducted a series of experiments on the hydraulics of fire streams, in which he found that the character of the waterway in the hose had a marked effect upon the friction loss or drop in pressure. Thus, with a badly corrugated mill hose, the drop in pressure per 100 feet with 240 gallons flowing per minute in 2½-inch hose, was found to be 25½ pounds, while with the smooth hose, the drop in pressure was only 14 pounds. In other words, if 200 feet of hose were being used in a line, it would require a pressure of about 73 pounds at the hydrant to give a good fire stream with good hose, while with poor hose it would require a pressure of 95 pounds.

In view of the importance of this matter, the question was taken up with a number of the largest hose manufacturers. In the numerous conferences which followed, the discussion spread from friction loss to include cotton fabric, rubber lining, bursting strength, elongation, etc. Practically all agreed that the fire hose situation, especially with respect to private equipment hose, needed improvement, and most of the manufacturers were in favor of specifications. Finally, after a large number of tests had been made and many lots of hose examined in the field, the first set of Underwriter Hose Specifications were agreed upon and published in July, 1896.

It should be mentioned that in these first specifications, it was originally suggested that all reference to the kind of rubber in the lining be omitted, but many of the manufacturers objected, stating that if the kind of rubber was not specified, some unscrupulous manufacturers would take advantage of those who were honest by using an inferior rubber. Accordingly a clause specifying the kind of rubber was inserted, and it was the consensus of opinion that 40 per cent. of pure Pará should be required. This unfortunate wording, which later gave rise to the question as to what was meant by pure Pará, has been the cause of more discussion than any other clause in these specifications. There is ample written evidence, however, to show that at the time the original specifications were written, and for several years after, everyone interested in hose specifications understood that pure Pará meant fine Pará.

The whole idea in this matter of specifications was to obtain a list of manufacturers whose product could be depended upon, and which could be recommended to mills insured in the Factory Mutual Companies. This idea had been and was being developed in many other lines of fire protection appliances at the same time. The plan of procedure used then, and which has not been changed in any important particular, was as follows: Any manufacturer desiring to have his hose placed upon the approved list, had only to make known his desire and send in samples of commercial hose for test. If the samples were found to conform with the specifications, his name was placed upon the approved list without charge for the tests.

In these early days, the words "Factory Inspection" were not used, but it was understood that representatives of the Mutual Companies would be welcome to visit the factories of the hose manufacturers at all times. Although no systematic plan of inspection was carried out, many such visits were made to the factories, and without objection on the part of the manufacturers.

From the time the first specifications were published in 1896, no change was made until 1900, and at that time the changes were of no great importance. In the meantime, the National Fire Protection Association had been formed and the Underwriters' Laboratories established. At this point it may be stated that although the National Fire Protection Association is a national association of those interested in the prevention of fire, in reality, through a large preponderance of members affiliated with stock insurance companies, it is controlled largely by the stock companies.

In 1889 the National Fire Protection Association adopted a set of specifications for hose which were very similar to the Factory Mutual Specifications of 1896, but enough different to cause some confusion among the manufacturers. It became evident at once that where these two organizations covered the greater part of the field, it was desirable that their specifications should be uniform. With this idea in view, a number of conferences were arranged, and finally a "National Standard" satisfactory to both parties was adopted in May, 1902. Only two important changes from the original specifications were made. One item regarding stretch of the rubber lining to five times its original length, which had appeared in the N. F. P. A. Specifications, was omitted, and another item requiring a test of 200 pounds on each 50-foot length, not originally in the Mutual Specifications, was added. From that time to the present the specifications for underwriter hose for both organizations have been essentially the same, although their ideas regarding the method of enforcement have differed widely.

The intervening years up to 1911 were occupied with the continual testing of samples from the field and from the factories and the gradual accumulation, especially in the later years, of evidence that most of the manufacturers of hose were not turning out a product made in accordance with the specifications. During this time the methods of rubber analysis and testing developed considerably, and the Insurance Laboratories made an effort to keep pace with the progress. In this way the number and character of the analyses and tests made in connection with the examination of hose gradually changed. It should be noted, however, that the chemical and physical tests which were used, were employed merely as laboratory standards with the idea of determining whether or not the specifications had been complied with. Owing to the fact that many points in connection with rubber testing had not been established with the same degree of certainty as in other lines of chemical work, some of the manufacturers did not neglect the opportunity to deny the findings of the laboratories, although in many instances the cases were so clear cut as to leave no question.

A typical example of this kind taken from many others, is one where a certain lot of hose which failed after four years' service was sent by the assured to the Factory Mutual Laboratories for test. An acetone extract of over 20 per cent. was found after deducting the free sulphur, and a small percentage of wax, and this, in connection with other chemical tests, showed beyond question that the requirements regarding rubber in the specifications had been seriously violated. Notwithstanding this evidence, the manufacturer steadfastly maintained that the lining contained only a mixture of fine and coarse Parás. He even went so far as to claim that he could show samples of Pará which would give an extract of 20 per cent. He also obtained a sample of the lining which he submitted to an independent chemist for analysis. Needless to say his proposal to submit a sample of Pará containing 20 per cent. resin extract never materialized, but a representative of the manufacturer called up on the telephone some time later and stated that he had a report from his chemist showing that the lining in question had consisted only of Pará, as he had claimed. He was requested to bring in the report, but although that was four years ago, it has not put in an appearance as yet, and the manufacturer finally agreed to replace the hose with another lot fully in accordance with the specifications and without charge to the assured. The hose was replaced in time and to make a long story short, suffice it to say that the second lot was no better than the first. The manufacturer was surprised to learn that we had tested the second lot, but after an extended controversy agreed to replace the hose again.

This case, although in some of its features a little more extreme than most of the others, is simply a sample of similar incidents that took place, and which made it very difficult for us to appreciate the position of some of the manufacturers whose integrity had previously never been questioned. These controversies also made it evident that before the hose situation could be definitely cleared up, it would be necessary to include as part of the specifications the laboratory standards which had been used in testing hose.

In the meantime, in 1906, the Underwriters' Laboratories of Chicago developed their system of "Label Service." In brief, this system required that an inspector should be stationed at the factory and inspect every length of hose sent out; also that each length should bear a label stating that the hose had been manufactured under the supervision of the Underwriters' Laboratories of Chicago. Samples of hose could be taken at any time and shipped to the Underwriters' Laboratories for more detailed tests than could be conducted at the factory. The labels were to be purchased by the manufacturers from the Underwriters' Laboratories at the price of 25 cents each. Owing to several objectionable features which it was found impossible to have removed in spite of a number of conferences, the label service has never been adopted by the Mutual Companies.

The proposition, although at first opposed by some of the manufacturers, was adopted by a few of them. Owing to various differences of opinion and controversies, however, these few manufacturers later dropped the labels and during 1909 and 1910, all of the manufacturers on the approved List of the Chicago Laboratories were dropped. The opposition to the label service on the part of the manufacturers was very bitter and for over a year their ranks were kept unbroken. In the early part of 1911, however, two of them submitted samples of hose to the Underwriters' Laboratories, which were approved, and adopted the label service. Later in the year another manufacturer followed. At the present time these three are the only ones using the labels.

The system has been developed, it is understood, until now the inspector at the factory supervises the washing of the crude rubber, the weighing and compounding of same and the calendering and making up of the tubes. In short, the rubber from the beginning of the manufacturing operations until the hose is completed is either in the inspector's presence or under lock and key kept in his possession. The tests which the specification require are made on every length, and are conducted in the presence of the inspector.

In 1908, the National Board of Fire Underwriters undertook the preparation of specifications for public fire department hose, both cotton, rubber-lined and rubber-covered. Regarding the history of the development of these specifications the writer has no detailed knowledge since the Mutual Companies have, as an organization, never taken a sufficiently active interest in this matter to warrant drawing up specifications for this class of hose.

In brief, however, it may be stated that after a long series of conferences between the National Fire Protection Association and the manufacturers, a set of specifications were drawn up which, at the time, were satisfactory to both parties, and which allowed a much lower grade of rubber than the present specifications. The manufacturers insisted, however, that these specifications should be used merely as a laboratory standard, and not furnished freely to purchasers. In other words, hose would be approved by the Underwriters' Laboratories without its becoming generally known that it was all made in accordance with a definite set of specifications. Whatever may have been the understanding, or misunderstanding, the specifications were used freely throughout the country by the Underwriters' Laboratories. The manufacturers accordingly cancelled their agreement and dropped all negotiations. The N. F. P. A. later worked out a much more stringent set of specifications which were proposed at the annual meeting in May, 1911, and formally adopted in May, 1912. The requirements regarding rubber lining in these fire department hose specifications are very similar to those contained in the underwriter hose specifications. The three manufacturers who have adopted the label for underwriter hose are also manufacturing label hose under the fire department hose specifications, which we already referred to.

As previously stated, the accumulated experience of the Factory Mutual Laboratories during the last five years showed that much more specific and definite requirements regarding rubber lining would have to be included in the specifications before the situation could be improved. A considerable amount of experience backed up with experimental work showed pretty clearly what was necessary to produce good hose, and a new set of specifications were accordingly drawn up in the latter part of 1910. At the same time the Underwriters' Laboratories prepared more definite specifications and presented them at the annual meeting of the National Fire Protection Association in May, 1911. The two specifications differed somewhat, however, and the matter was referred back to the Hose Committee in order that the two organizations might have an opportunity of agreeing upon a uniform standard. A number of conferences followed and a specification was finally drawn up satisfactory to both organizations. It was formally adopted by the Factory Mutual Companies in December, 1911, and by the National Fire Protection Association in May, 1912. Owing to the various delays, the Mutual Companies have not yet put these new specifications into effect, but in the near future the manufacturers of underwriter hose will be notified that after a certain date, approval will be withdrawn in cases where the hose is not made in accordance with the new specifications. The specifications have already been sent to the manufacturers and in a few cases they have voluntarily expressed their satisfaction with them and stated that they were heartily in favor of the change.

The most important points where the new specifications differ from the old are with respect to the rubber lining. The change consists simply of a more definite statement of what was required in the old specifications. The new specifications call for 40 per cent. of fine Pará instead of pure Pará, and specify tests which the compound must meet, including acetone extract, free and total sulphurs, alcoholic potash extract, tensile strength, elongation and the so-called permanent set.

In closing, it may be stated that the only object of the Mutual Companies in this matter of hose specifications is to make it possible for their members to obtain good hose. The work of testing and inspection is done without charge to the manufacturers, and it has always been the intention to treat them fairly and co-operate with them as far as they would allow.

Referring to the situation in 1908 between the manufacturers and the National Fire Protection Association the author says:

"It may be stated that after a long series of conferences between the National Fire Protection Association and the manufacturers, a set of specifications were drawn up which, at the time, were satisfactory to both parties, and which allowed a much lower grade of rubber than the present specifications. The manufacturers insisted, however, that these specifications should be used merely as a laboratory standard, and not furnished freely to purchasers. In other words, hose would be approved by the Underwriters' Laboratories without its becoming generally known that it was all made in accordance with a definite set of specifications. Whatever may have been the understanding, or misunderstanding, the specifications were used freely throughout the country by the Underwriters' Laboratories. The manufacturers accordingly cancelled their agreement and dropped all negotiations."

Contracts.

By

A. W. STEDMAN.

Buying and selling is as old as the world's history. From the earliest ages men have exchanged commodities for their equivalent in the recognised standard of value. Whether the object was grown or produced by themselves, or bought from distant countries, the same general principle applied.

The bringing of the products of far-off countries to central markets has at all times constituted an important feature of the merchant's profession. The trades of Tyre and Sidon, and their successors of Venice and Genoa, carried to the limit of its then possible development the importation of exotic products from the Far East. Had the Western Continent been known to them, it is to be assumed that they would have also handled the various articles which form its natural wealth, and perhaps rubber.

With the growth of modern commerce, new methods of trading became necessary. Instead of the simple exchange of goods for money and money for goods, the operation of sale became divided, the contract and execution taking place at different times and often in different countries. The question of the " Casus Foederis " then assumed international importance, forming the corner stone which supported the business structure.

AGREEMENTS AND CONTRACTS.—Whatever may be the subject of a definite arrangement between two or more parties, the common law presupposes that there has been a " Consensus ad unum " between the parties concerned. This consent or agreement, though not necessarily in all cases in writing, is usually recorded and expressed in that form for various reasons. One or other of the parties may die or change his residence, while the writing remains to prove the transaction. Moreover, even when both parties are accessible, the existence of a properly drawn contract saves time and trouble in the establishment of legal rights. The results accruing from a badly made or inadequately drawn contract are far reaching.

All business is done on confidence between man and man. We have often heard the remark made, " I would as lief have that man's word as have his bond," and, fortunately for the business world, the large majority of men are honest and well meaning, with the intention of carrying out their agreements. The term " Contract " in reality, therefore, means the putting into writing what has been agreed upon, so that if memory fails it can be referred to.

Following up this line of interpretation, a contract has been defined by modern legal authorities as the union of two or more persons in the declaration of their will, with the object of creating a future obligation between them. It has likewise been defined as recording an agreement between two or more parties for the doing or not doing of some particular thing. So far as to the agreement forming the essence of the contract itself.

The contract expressing such agreement should be drawn as to be enforcible by law. It should, moreover, be made upon sufficient consideration, and under circumstances that a breach of same constitutes a good cause for action. In this sense it is understood not to be lacking in any element necessary to constitute a legal obligation. Hence the contract expresses the agreement, therefore the importance that both parties coincide in all essential particulars is apparent.

While promissory notes have been regarded as unilateral, or one-sided contracts, the usual form of a contract is bi-lateral, or two-sided, binding two or more parties to mutual obligations. To use the colloquialism : " It takes two to make a bargain."

CONSIDERATION.—Consideration is an element of a contract, whether in the form of some actual object or service, or in the formal guise of " one dollar and other good and lawful considerations," in which a consideration is often expressed. This last-named form is not merely a piece of legal verbiage, but is the expression of fundamental theory of common law. "Nothing for nothing" is a proverbial saying, directly applicable to contracts.

CONTRACTS OF PURCHASE AND SALE.—Contracts are of as many kinds as are represented by the diversity of human interests. Conveyance of property, partnership agreements, trusteeships, marriage settlements, and other matters in which divided interests exist, necessitate contracts, but the one most applicable to mercantile transactions is that of purchase and sale.

From the smallest housekeeping purchase to the most extensive transactions in produce, the same general principles rule. In the first place there must be an agreement as to what is being purchased; second, a certain standard of quality is expressed or understood; and third, delivery must take place at a certain time and place within definite limits. Again, it must be arranged at what part the seller's responsibility ends, and that of the buyer commences. Another point to be defined is the mode of settlement.

But all contracts made are not fulfilled, and it is a wise precaution to stipulate the course to be pursued should one of the parties fail to carry out his part. Such failure may imply the vitiation of the contract with or without a penalty being incurred by the offending party. Such are a few of the chief points affecting contracts of purchase and sale in general; and applicable to the consideration of rubber contracts in particular.

RUBBER CONTRACTS.—Bringing rubber from one part of the world to another includes the simpler form of business, in which produce existing at a central point (New York, London, Liverpool, Antwerp, etc.) is shipped to its destination in execution of special orders.

The European or American rubber manufacturer has only the risk of a possible difference between the merchandise and the samples of exact parcels submitted. With a careful buying agent watching his interests at the auctions and in the open market, this risk is but slight, as the price will have been based upon trials of samples and not merely on standards or descriptions. This "spot" business may have its advantage, but as the market is often bare of desirable stock, and as manufacturers are often desirous of covering their sales of the manufactured product with the necessary crude rubber, forward orders have become a necessity in the rubber trade almost as much as they have in the cotton business.

The forward rubber trade depending upon standard classification requires to be done under contracts, in which the importers, instead of selling the actual rubber in hand, engage to deliver certain quantities of a known grade. Those who have not had experience have no idea of the risks which an importer takes in selling at prices in American currency for delivery either at New York or at the mill; thereby relieving the buyer of a mass of troublesome formalities and details.

Such business, whether for early or deferred shipment, needs, however, the safeguard of a contract protecting alike the interests of buyer and seller, and the most disastrous results are likely to result with merchandise as valuable as crude rubber from badly drawn contracts. With this view a few of the salient points claiming attention may be recalled.

POINTS OF RUBBER CONTRACTS.—On this subject it will be of interest to recall the principal feature of the standard rubber contracts for forward orders adopted by Liverpool and London. This contract embodies detailed provisions as to the three parts of tendering, inspection, and arbitration, which constitute the chief features of the operation in view.

Moisture in Rubber.—In addition to these formal points, rubber manufacturers have, moreover, calculated on the shrinkage of the crude material, in the same way as woollen manufacturers have to base their calculations on the scoured cost. In the case of standard Argentine wools, the foreign shippers guarantee a fixed percentage of loss in scouring. The large manufacturers by whom the wool is imported find the actual scoured result and settle on that basis, paying or deducting any difference between the actual and the guaranteed scoured weight. Whether such a principle is applicable to rubber is a question worth considering. Analysis has brought out the percentage of moisture with scientific accuracy as shown by the recent series of experiments at the Imperial Institute, London. The application to rubber of the system of " conditioning " (applied to silk) has also been proposed. By this system, the absolute dry weight, obtained by baking in special apparatus, is increased by the percentage of normal atmospheric moisture; settlement being made on the basis of " condition " weight thus established. We have a similar establishment in New York, and the subject of moisture in rubber has, I believe, received attention from the National Bureau of Standards, Washington.

The importance of the question of moisture in rubber is shown by the fact that the price paid by the manufacturer depends not only upon the grade, but also upon its dryness and cleanliness. Years ago, when it took months some to get Fine Para into the market, the water had dried out of it, so that " Old Fine " meant a comparatively dry rubber. To-day, with the much quicker transportation and the immediate use to which rubber is put, most of the grades are found to contain a much larger percentage of moisture than formerly.

Standard Qualities of Rubber.—Attention has been paid in Europe to the question of the establishment of standard grades of plantation rubber, to which planters would conform, in order to facilitate regularity of delivery. In this way contract business would be facilitated. Such an arrangement would naturally be to the advantage of the planters, by making their produce of more current sale for late delivery. Forward orders extending over the year 1913 have largely been for well-known grades of plantation rubber, and the question is asked why this system is not more generally applicable.

Forward contracts imply uniformity of quality, and this is more particularly attainable with rubber, in which there is a natural uniformity between the latex of trees at various stages of development. It has been asserted that like processes of cultivation and preparation will always, under like circumstances, produce like results.

Forward Orders.—The growing importance of the rubber industry has shown manufacturers the necessity of making provisions in advance for their supplies. Hence the formal purchasing contract is more and more frequently used in the trade, not only for rubber on spot, that practically in sight, for delivery within a few months, but specially for that which will not be available for a year or more.

Under these circumstances the question arises, " How are the interests of buyers and sellers to be reconciled under a standard form of contract ? " Such a form should provide not only for the course to be taken when all goes well, but likewise for the steps to be taken in the event of non-delivery, late delivery, or refusal of tendered rubber. The possible application of one uniform contract to transactions in various kinds of rubber, from various countries, is another point for consideration. I fully realise the difficulty in formulating terms and conditions to cover the purchase and sale of rubber in the South or in the East, and have the same forms apply in the markets of Europe and America, but that some equitable form can be evolved, to the benefit of all well-intending men, I am quite convinced.

Standard contracts applicable to forward delivery exist in other branches of imports; the Silk Association of America having given special attention to the subject.

RUBBER SELLING CONDITIONS.—The following general summary of the principal conditions indicates the chief points to be covered in any standard rubber contract :—

1. The seller draws up, signs, and sends a contract to the buyer, stating conditions of sale. Formerly, silence on the part of the buyer was taken to mean acceptance of the contract, but it was found that misunderstandings resulted, and now it is the uniform custom for the seller to send to the buyer two signed contracts, one of which he keeps and one of which he returns with his acceptance written thereon.

2. Any objection to the terms expressed in the contract must be made immediately upon receipt, and any changes must be in writing signed by both parties.

3. Provision should be made for delays in transportation. If the rubber is shipped by a steamer due to arrive at port of destination within the contract period, buyer must accept delayed delivery upon receipt of proof of sailing and reason for delay.

4. If any part of the rubber is lost at sea, contract is to be voided for that portion.

5. The rubber becomes the purchaser's property as soon as it leaves the seller's hands, the buyer paying the freight and cartage.

6. Seller's responsibility for goods in transit ceases when they pass into the hands of the transporting company. Stealage or other loss while en route is at the buyer's risk.

7. If the shipment is questioned as to quality, and if bought by sample, this is compared, and, in case of dispute, to be decided by arbitration, the losing party to pay the costs of arbitration.

8. The buyer is not allowed to select the good and reject the bad from any lot, he must take all or none.

9. If the seller fails to make delivery on or before the last weekday of the month specified and no proof is offered that the delay was caused beyond seller's legal control, the buyer can enter the open market and purchase, charging any loss to the seller.

STANDARD CONTRACT WANTED.—The endeavour to cover all the essentials in an agreement with a knave is practically a hopeless task. It would be difficult to find a solicitor of sufficient ability to draw a contract, which another solicitor of equal acumen cannot break or so modify that his client, if he be so inclined, is enabled to secure an advantage to which he is not justly entitled.

The fair-minded seller means to deliver what he has bargained to supply, and the honest buyer means to accept and pay for what he agreed upon. It only remains, therefore, to find and agree upon fair and equitable terms and conditions which will prevail and become known the world over as the usual basis upon which crude rubber is bought and sold.

Report of the Rubber Committee of the American Society for Testing Materials: Standard Specifications for Rubber Products.

By

E. B. TILT,

Chairman of the Committee.

The Executive Committee of the American Society for Testing Materials, appointed in December of 1911, a committee known as "Committee D-11 on Standard Specifications for Rubber Products." The first meeting for organization and the appointment of sub-committees was held in New York in February, 1912, and another meeting was held in New York in March, 1912, for a continuation of the organization and the distribution of work. Since then the sub-committees have been completing their organizations and gathering information relative to their work and data upon which to base specifications. Another meeting was held in September, 1912, in New York, and the present situation with reference to specifications on rubber products and the work of the different sub-committees was discussed. It is expected that a report of material progress, with perhaps one or more specifications covering rubber products, will be presented at the Annual Convention of the American Society for Testing Materials to be held in 1913.

The organization of a committee on Standard Specifications for Rubber Products by the American Society for Testing Materials is due to requests from a number of sources that a committee be organized to draw up specifications covering the following: Rubber Tubing, Air Hose, Steam Hose, Hot-water Hose, Cold-water Hose, Rubber Belting, Gaskets and Rubber Insulation, as well as Rubber Inner Tubes and Casings for Automobile Tires. Sub-committees have been appointed for all of these, excepting Rubber Tubing, Inner Tubes and Casings for Automobile Tires. In addition, sub-committees have been organized to gather data for specifications for rubber valves and for rubber tiling, and it is probable that committees will be appointed to cover cement, rubber rolls and other important rubber goods just as soon as the work at present in hand will permit.

It is expected that the specifications which are to be forthcoming will cover each product with tests, physical or chemical, or both, with instructions for making these tests, as well as description in detail of the construction desired, together with such physical dimensions as will permit of the manufacture of a standard product. It is not intended that other than commercial materials or articles shall be described by these specifications, and where necessary different grades will be included in the same specification, with such difference in the tests as may fix the limits. The intent is not to hamper the manufacturer, but to assist him to establish standards which will be the basis for the making of a reasonable price and which we hope will also be the guarantee of reasonable service.

It is unnecessary to debate upon the advantage from the consumer's point of view, of securing standard material in rubber products. Many of us are familiar with the difference in service given by similar materials, sold by different manufacturers. It is for this reason that standard materials are at this time most necessary.

The question as to what extent chemical analyses will be a part of these specifications, it is impossible now to answer, but each material will be covered by a chemical analysis in so far as our present information warrants such analysis; but the dominating feature of these specifications will be physical tests of as simple a character as is consistent with the characteristics it is intended to expose and the service demanded of the material.

The American Society for Testing Materials is fortunate in being able to select from its members a committee which represents the producer and the consumer, and the regulations governing technical committees are very clear on this point as they read: "On committees dealing with subjects having a commercial bearing, either an equal numeric balance shall be maintained between the representatives of consuming and producing interests; or the former may be allowed to predominate with the acquiescence of the latter. Unattached experts shall be classed with the representatives of consuming interests." This means that a committee will include men having the data relating to the service given by material as well as men having knowledge of the theory and technique of manufacture. It seems to us that the only other essential to make a specification which may be pronounced a success is the use of judgment in its application. It is intended of course to co-operate with all other societies having similar interests in so far as that is desirable, as well as to do such additional research or investigation as may be required.

If I may be permitted to say a word about specifications generally, I should like to add here that the manufacturers who fear a specification have been unfortunate in their experiences with the use of specifications, and I can truthfully say that after a number of years' experience on various materials, bought with and without specifications, that the greatest satisfaction has been on those materials covered by a specification. Referring to rubber particularly I may say that the most satisfaction is gotten with the material at present bought on specification. I am not prepared to say that the unspecified materials are not made as good as they would be if covered by a reasonable specification. It is, however, a fact that a great deal of dissatisfaction exists in the use of these materials. A guarantee of service by a reputable maker is, in the abstract, the sweetest thought that ever consoled a purchasing agent worried with the fear that he was not getting value for the purchase price. It may be possible in a closely consolidated plant to take advantage of a guarantee, but on a large railway, a guarantee on small rubber mechanical goods is probably not worth the time of consideration.

Our policy in drawing up these specifications will be to do justice to manufacturers and consumers alike, and we shall be open always to suggestions or ideas from those interested in our work. We may go further and say that we invite criticism, though we realize that we cannot hope to satisfy all. It is believed that progress is made when the majority are satisfied. We would welcome to membership on our committees any of those here now or any others who are interested, and again we can assure the manufacturer and consumer that our attitude is that of friendliness and a desire for progressive co-operation.

Regarding the use of specifications that we may offer, we believe that the governments of the United States and Canada, and large corporations such as railways, will welcome them, and as a recompense for our work we shall have the satisfaction of knowing that their use will be immediate and general, if not *in toto*, at least in their main essentials.

Report of the Rubber Section of the American Chemical Society.

By

D. A. CUTLER,

Chairman of the Section.

PRESENTED AT THE THIRD INTERNATIONAL RUBBER CONFERENCE.

In regard to what the Rubber Section of the American Chemical Society is endeavoring to accomplish, I would say that in the first place it aims to select or to elaborate standard methods for the analysis of vulcanized rubber products, and to define these methods with sufficient precision so that they will yield accurate results.

Having agreed upon such a series of analytical methods, the Section will endeavor to secure for them the endorsement of the American Chemical Society. If successful in this, the methods will then be published as the official methods of the Society. The great advantage of such official methods would lie in the fact that analyses made according to them would possess, in very high degree, impersonal validity. This would be an indispensable factor in cases of dispute, whether forensic or not, and in all cases in which the public might be concerned.

On the other hand, with reference to individual practice, our Section would have no desire to urge unduly the adoption of the official methods, but we do permit ourselves to hope that these methods will so commend themselves by their evident and inherent practicability, definiteness and accuracy, that chemists will be glad to adopt them in their practice.

In the second place, our committee is endeavoring to bring about uniformity in the manner of stating the specifications to which consumers wish the manufacturers of rubber goods to conform.

As to this matter we do not wish to be misunderstood. Our aim is not at all to formulate specifications of any sort, much less to impose them upon anyone. For if it is the province of the consumer to specify the goods which he will accept, and if it is equally the province of the manufacturer, after studying his market, to decide what goods he will make, we have no desire to interfere.

What the Section hopes to do in this field is to provide official terms and phrases and to define them so carefully and precisely that the consumer may state his specifications by means of them, if he will, without any ambiguity.

At present the Rubber Section of the American Chemical Society has over 100 members. These include nearly all the manufacturers of rubber products, as well as a great many consumers. The committee believes itself, therefore, to be in possession of exceptional facilities to serve both these interests.

There is no desire on our part to gain any information, or to pry into any processes or policies which the interested representatives may wish to guard, but it is our sincere desire to do what we may along the lines indicated, to minimize the chances of ambiguity, confusion, and misunderstanding between the manufacturers and consumers of rubber goods.

APPENDIX.

OPENING CEREMONY.

INTERNATIONAL RUBBER BANQUET.

Press Lunch and other Functions
held in
connection with the Exhibition.

OFFICIAL COMMISSIONERS AND DELEGATES TO THE EXHIBITION.

(Countries arranged alphabetically.)

ANGLO-EGYPTIAN SUDAN: H. P. Hewins, Esq.
ARGENTINE (Republic of): Don Arturo Parker.
BELGIUM (Belgian Congo): Captain Commandant Leon Osterrieth.
BRAZIL—State of Amazonas: Snr. J. Rodrigues Vieira.
Do. Bahia: Dr. Jayme de Argollo Ferraõ Jor.
Do. Pará: Snr. José Amando Mendes.
Snr. Emilio Martins.
Dr. Souza Castro.
Colonel Raymundo P. Brazil.
Dr. Theodoro Braga.
Snr. Jayme Abreu.
Do. São Paulo: Dr. Edmundo da Fonseca.
COMMERCIAL ASSOCIATION OF THE AMAZONAS:
Snr. N. H. Witt.
Snr. Hugo Ohliger.
Colonel Leopoldo de Mattos.
COMMERCIAL ASSOCIATION OF PARÁ:
Snr. José Amando Mendes.
CEYLON: R. N. Lyne, Esq., F.L.S., F.R.G.S.
COLOMBIA (Republic of): Don Francisco Restrepo-Plata.
EAST AFRICA PROTECTORATE: H. Powell, Esq.
EGYPT: James Hay, Esq.
FEDERATED MALAY STATES:
Malay States Information Agency.
Sir Wm. Taylor, K.C.M.G. (Agent).
F. J. Ballantyne Dykes, Esq. (Deputy Agent).
Leonard Wray, Esq., I.S.O.
FIJI: The Imperial Institute.
FRANCE AND COLONIES:
Algeria
Cambodia
Cochin-China
Dahomey
French Guiana
French Guinea
Gaboon
Haut-Senegal-Niger } Professor Emile Perrot.
Ivory Coast
Madagascar
Middle Congo
Morocco
New Caledonia
New Hebrides
Senegal
Tunis
Equatorial Africa: Monsieur Fernand Rouget.
Indo-China: Monsieur Andre Cremazy.
Occidental Africa: Monsieur Georges Francois.
GERMANY—Samoa: Mr. Wolff (Vice-Consul).
GUATEMALA (Republic of): D. Bowman, Esq.
KELANTAN (State of): T. Clifton Hutchings, Esq.
NETHERLANDS: Java
Dutch Guiana } H. S. J. Maas, Esq., K.N.L.
St. Eustatius
NIGERIA: W. H. Johnson, Esq.
PHILIPPINE ISLANDS: O. W. Barrett, Esq.
PORTUGUESE WEST AFRICA: Viscount de Pedralva.
QUEENSLAND: The Agent-General.
SIERRA LEONE: William Hopkins, Esq.
UNION GOVERNMENT OF SOUTH AFRICA: C. du P. Chiappini, Esq.
WEST INDIES:
Montserrat
St. Lucia } Algernon E. Aspinall, Esq.
St. Kitts
Antigua: H. A. Tempany, Esq., B.Sc., F.I.C., F.C.S.
British Guiana: C. W. Anderson, Esq., I.S.O.
British Honduras: The Hon. H. L. McKinstry.
Dominica: H. A. Alford Nicholls, Esq., C.M.G.
St. Vincent: W. N. Sands, Esq.

THE
FOURTH INTERNATIONAL

RUBBER EXHIBITION

1914

FIRST INTERNATIONAL

COTTON, FIBRES,

AND OTHER

TROPICAL AGRICULTURAL PRODUCTS EXHIBITION

1914

"The Great Rubber Exhibition"
"*The Times*" *leading article, 26th June*, 1914.

FOURTH INTERNATIONAL

RUBBER AND ALLIED INDUSTRIES EXHIBITION

Patron—
HIS MAJESTY THE KING.

President—
Sir Henry A. Blake, G.C.M.G.
(ex-Governor of Ceylon, Bahamas, Newfoundland, Jamaica, Hong-Kong, &c.)

Vice-Presidents—
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The Earl of Denbigh, C.V.O.
The Viscount Kitchener, G.C.S.I., G.C.V.O.
The Lord Elphinstone.
Professor Wyndham Dunstan. C.M.G., LL.D., F.R.S.

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COTTON, FIBRES, AND OTHER TROPICAL AGRICULTURAL PRODUCTS AND ALLIED INDUSTRIES EXHIBITION

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Prof. Wyndham Dunstan, C.M.G., LL.D., F.R.S. (Director, Imperial Institute; President of the International Association of Tropical Agriculture).

Vice-Presidents—

The Earl of Derby, G.C.V.O. (President of the British Cotton Growing Association).

The Earl of Scarbrough K.C.B. (Chairman, The Niger Co.).

The Viscount Kitchener, G.C.S.I., G.C.V.O.

Sir Henry A. Blake, G.C.M.G. (ex-Governor of Ceylon, Bahamas, Newfoundland, Jamaica, Hong-Kong, &c.).

Miss D. Fulton,
Secretary.

A. Staines Manders,
Manager.

Exhibition Offices:
75, CHANCERY LANE (Holborn), LONDON, W.C.

OPENING CEREMONY.

WEDNESDAY, 24TH JUNE.

The official opening of the Fourth International Rubber and Allied Trades Exhibition, and the First International Cotton, Fibres and other Tropical Agricultural Products Exhibition took place on Wednesday, the 24th June, 1914, the ceremony being performed by His Royal Highness Prince Arthur of Connaught. The President of the Rubber Exhibition, Sir Henry A. Blake, G.C.M.G., with Prof. Wyndham R. Dunstan, C.M.G., the Right Hon. Mr. Lewis Harcourt, M.P. (Secretary of State for the Colonies), the Executive and Reception Committees of the Exhibition, viz., the Right Hon. Lord Elphinstone, Sir William Taylor, K.C.M.G. (Federated Malay States), Sir Edward Rosling (Ceylon), Messrs. John McEwan, J.P., Arthur Lampard, Cyril E. S. Baxendale (Planters' Association, Federated Malay States), Joseph Torrey, Ph.D. (Chairman of the Congress), the Hon. Everard Feilding, C. O. Macadam (Ceylon), Noel Bingley (Java), F. Pegler, R. Croll, Philip Schidrowitz, Ph.D., Miss D. Fulton and A. Staines Manders, received His Royal Highness, who was accompanied by Captain Eric Bonham, Equerry, and conducted him to King George's Hall, where the opening ceremony took place, in the presence of about two thousand visitors from all parts of the world. On the daïs, in addition to those already mentioned, were the Hon. Mrs. Lewis Harcourt and Mrs. John McEwan.

Sir HENRY BLAKE, on rising, said: Your Royal Highness, I desire on behalf of the Committee of the International Rubber and Allied Industries Exhibition to express their gratitude to you for the honour that you have done them in graciously consenting to open the Exhibition. This is the third of a series of Exhibitions that have been held in London in connection with the Rubber Industry. The first was in 1908, and the second in 1911. The objects of the Exhibition are, primarily, to bring together the rubber producers of all countries and the manufacturers with a view to increasing our knowledge of the necessary conditions for the successful planting, growing, preparing and marketing of rubber, and of stimulating the discovery of new lines of expansion for its uses. But beyond this, we shall have during the Exhibition a series of Conferences at which papers will be read and discussed by practical experts from every part of the rubber-producing world, these lectures and discussions being preserved in book form, as has been done in the former Exhibitions, and the result being a valuable record for future use. That these Exhibitions have been so successful is due in a great measure to the untiring energy and organising ability of Mr. Staines Manders, the Organising Director. The importance of this great rubber industry is shown by the fact that the amount of capital invested is over £250,000,000 sterling. Fifty-four Governments have taken part in the Exhibition, to which official delegates have been appointed. Besides the rubber, which forms the principal part of the Exhibition, there are important exhibits of cotton and other fibres, on the assured supply of which the prosperity of our British trade so much depends. The Exhibition is international in its widest sense, and its amicable rivalry in assisting the common progress affords the surest basis of international friendship by the cementing power of community of commercial interests. I have the honour to request that Your Royal Highness will declare the Exhibition open. (Applause.)

Prince Arthur of Connaught, who was enthusiastically received, said: Sir Henry Blake, your Excellencies, ladies and gentlemen, let me first express to you my grateful thanks for the kind words in which you have alluded to me in your address, and also assure you how much I have appreciated the honour of having been invited to take part on such an important occasion in the history of the rubber industry to-day. (Applause.) After the interesting speech to which we have all listened, I feel that it would be mere presumption on my part to detain you long on the question of synthetic or any other form of rubber, of whose comparative merits I confess that I am entirely ignorant; but I may say that I gladly complied with the request that I should open this Exhibition, for I am firmly convinced that few things tend more to the welfare of mankind than that men of all nations should from time to time meet together for the promotion of branches of industry to which they are devoting their brains and their lives. (Applause.) Consequently, it is a source of very great satisfaction to me to welcome here to-day the official delegates from so many different countries, who are assembled here this afternoon and engaged in amicable trade rivalry with ourselves, for the purpose of stimulating the growth of this wonderful industry. Well, gentlemen, there is an old saying to the effect that "every dog has his day," and from the innumerable prospectuses which used to cover—I dare not say litter my writing-table every morning, I think I can safely say that rubber has, is having, and will continue to have its day. The latter half of the nineteenth century was essentially the gold mining era; but I do not think that I am far from the mark in saying that the glutinous product which is found in a variety of trees in Africa, Asia, and South America, and which has been introduced with such success into Ceylon, Malay States, Straits Settlements, etc., will, in due course, in its own sphere of production, prove as profitable as the production of the golden mineral in the future. I feel that I am laying myself open to the accusation of dabbling or investing in rubber shares, so I hasten to deny the impeachment; but I do feel that a boom in some department of industry would be very welcome, so why not another in rubber? (Applause.)

I believe I am right in saying that the first specimens of crude rubber were brought to Europe by La Condamine in 1735, but nothing was made of the raw material until 1770, when Dr. Priestly called the attention of the public to its value for erasing pencil marks. Charles Macintosh, early in the nineteenth century, introduced waterproofing cloth, which really marks its beginning as a commercial product. Since then, thanks to that veteran of travel, Sir Clements Markham, who did so much towards the introduction of the cinchona cultivation to the East, and to the skill of Mr. H. A. Wickham—(applause)—seeds of rubber-bearing trees were first transported to Kew Gardens and then sent to Colombo, Burma, Mauritius, Singapore, Java, and Fiji, which has led to a very rapid development, something like 70,000 tons being exported to this country in 1913. Not unnaturally, however, this enormous production is for the moment in excess of immediate requirements, which has occasioned a fall in prices—hence the reason of this Exhibition, to show the people of this country the variety of purposes and uses to which the material can be applied, and which offers such a vast untrodden field for future commercial enterprise. In conclusion, gentlemen, I will not detain you any longer, as your time will be far more profitably employed in seeing the wonderful exhibits for yourselves than listening to any further remarks from me, and it only remains for me to wish this Exhibition every possible success and to say that I feel convinced that it will conduce in no small measure to the advantage of this important and ever-growing industry for the benefit of all mankind. (Applause.)

The Right Hon. LEWIS HARCOURT, M.P. (Secretary of State for the Colonies): Your Royal Highness, your Excellencies, ladies and gentlemen, I am, of course, deeply interested officially in the rubber production of the British Empire. It is an industry the birth of which in our territories coincides with the dawn of the present century, but its growth during the time which has elapsed since then has been beyond expectation and almost beyond belief. Last year the exports of rubber from the Straits Settlements, the F.M.S., and Ceylon alone reached the extraordinary total of 71,000,000 lb. in weight and a value of £11,000,000. The production in the first five months of this year show that the total output for 1914 is likely to exceed in quantity anything which has preceded it. It is quite true that the price per pound has fallen as compared with previous years. The price of rubber is naturally regarded from different points of view by different interests and individuals. Those whom you will probably see at this Exhibition will be the consumers, and to them a fall in the price, like another well-known commodity, might be described as grateful and comforting. However, I am more concerned officially with those who produce the commodity in our Crown Colonies and Protectorates, by whom a decrease in their profits on the raw material is received with somewhat less enthusiasm. I have mentioned only our Eastern Colonies and Protectorates, but it must not be forgotten that rubber is produced on plantations and from wild trees and vines in many of our African colonies on both the East and West coasts, and the owners may well look with some trepidation upon the low cost of profitable production in other parts of the world, which is illustrated in this Exhibition. The theory of political economy and the teaching of experience prove that cheaper production increases the demand and extends the use of a material. By users of motors—and who, indeed, in these days, does not come under that head?—there will be a very warm welcome for any set-off against the high price of petrol in the total of their tyre expenditure. Now, although neither the British nor the Colonial Governments subsidise commercial industries, it should not be forgotten that indirectly great assistance is given in all our dependencies by the establishment of agricultural departments, botanical stations and model plantations. The work of the schools of tropical medicine, and the anti-malarial campaign have contributed to the health and efficiency not only of the labourers, but of the management staff. The Entomological Research Committee, under the presidency of Lord Cromer, has rendered great services in the study and extermination of insect pests. and the Rubber Growers' Association have themselves established and financed admirable research institutions in Malaya and Ceylon, whose work is contributing much to the common stock of our knowledge of the subjects. I am glad to see in this Exhibition a number of samples of other tropical colonial products which may be grown in association with, or, if necessary, as an alternative for, rubber, including fibres, cotton, coffee, cocoa, and oil from the fat-yielding nuts. Each of those is a staple commodity in its district and an important industry to the natives, for whom we have undertaken both national and Imperial responsibilities. Speaking for the Colonial Office and the interests which it represents, I desire to express our gratitude to the Rubber Growers' Association for organising this Exhibition, and especially to your Royal Highness for the encouragement you have given them by your speech and your presence on this occasion. (Applause.)

Mr. JOHN McEWAN: I, as Chairman of the Rubber Growers' Association, have been invited to express the thanks of all those interested in this Exhibition, to His Royal Highness, Prince Arthur of Connaught, for his kindly rendered services in coming to open the Exhibition. The Association referred to is only a young one. It celebrates the seventh anniversary of its birth this very day, but, for a seven-year-old child, it has a lot to show. Its interests are with plantation rubber only, and it now numbers 383 company members and 219 individuals. It represents a land area of 2,271,000 acres, of which 665,000 acres are planted in rubber. The issued capital of the companies at par is £42,750,000, but many of the shares stand at large premiums. Practically none of the companies were producers when the century came in. The objects of the Association are to improve our methods of working at the estates and at home; to study the science of our business with a view to increasing the yields and lowering the costs of production; to attract public attention to plantation as contrasted with all other sorts of rubber; and to find new uses on as large a scale as possible for what we produce. We look upon this Exhibition as an object lesson to producers, manufacturers and consumers, and we thank your Royal Highness for assisting, by your presence to-day, in giving it greater publicity than it would otherwise have received. (Applause.)

At the conclusion of the opening proceedings His Royal Highness and the Right Hon. Mr. Lewis Harcourt were escorted round the Exhibition by Sir Henry Blake and members of the Committees and introduced to the Commissioners of, and Delegates from, the various exhibiting countries, after which His Royal Highness visited the Rubber Tennis Court and watched with great interest the first match ever played on a rubber court. The ceremony and visit to the different exhibits occupied about two hours. His Royal Highness complimented the organisers on the arrangement of the Exhibition.

SIR HENRY AND LADY BLAKE'S RECEPTION.

After the conclusion of the Opening Ceremony, Sir Henry and Lady Blake held a Reception and entertained their guests at tea. Several hundreds of visitors attended.

The following cables were received on the opening day. The President and Committee much appreciate the kind thought of the senders :—

June 18th. STATE OF PARÁ. " Very sorry cannot attend personally kind invitation to International Rubber and Allied Industries Exhibition. I will inform you and beg you please communicate to Sir Henry Blake and the Exhibition Committee that the representatives of Pará are Mr. Emilio Martins, Mr. J. Amando Mendes, Mr. A. Souza Castro, Mr. Raymundo Brasil, Mr. Theodoro Braga, and Mr. Jayme Abreu. Mr. Amando Mendes will be the official delegate of the State of Pará at Conference held during the Exhibition. Very cordially. ENEAS MARTINS, Governor of the State of Pará, Brazil.

June 23rd. PLANTERS' ASSOCIATION OF MALAYA. " Best success to Rubber Exhibition."—Batang Padang District Planters' Association, Malaya.

June 24th. COMMERCIAL ASSOCIATION OF THE AMAZON. " Best wishes to all members Rubber Exhibition ; Amazonas pioneer and sole explorer of hard fine rubber thanks to competition will be forced to increase production, improve quality and reduce cost of production which is possible."—Associacao Commercial.

June 23rd. RUBBER CLUB OF AMERICA. " Greetings from Rubber Club of America."—HARRY S. VORHIS, Secretary.

June 23rd. PLANTERS' ASSOCIATION OF INDOCHINA. " Greetings. President officials wish success Exhibition prosperity rubber."—JACQUE, President, Planters' Association, Indochina.

June 25th. *BULLETIN FINANCIER*, INDOCHINA. " We participate fully in thought and heart in your great manifestation and congratulate your honourable Committee on their initiative in encouraging so greatly the development of colonial agriculture."—*Bulletin Financier*, Indochina.

June 24th. COMMERCIAL ASSOCIATION OF PARÁ. " Commercial Association Pará, celebrating Rubber Day, sends greetings Staines Manders, esteemed organiser, London Exhibition. Confident undertaking tend greatly increased progress of world's rubber industry."—REBELLO JUNIOR, President. BARREIROS LIMA, Secretary.

The International Rubber Banquet.

PRINCE'S RESTAURANT, PICCADILLY.

JULY 7TH.

The Fourth International Rubber Banquet in connection with the Exhibition and Congress was held on Tuesday, July 7th, at Prince's Restaurant, Piccadilly, the chairman being Sir Henry A. Blake, G.C.M.G., the President of the Exhibition. On his right were Professor Emile Perrot (of the Ecole Supérieure de Pharmacie of the University of Paris, and Commissioner-General of the French Government to the Exhibition), Dr. Edmundo da Fonseca (Commissioner-General of the State of Saõ Paulo, Brazil), Monsieur G. François (Delegate of the Government of French Indo-China), H. S. J. Maas, Esq. (Consul-General for the Netherlands and Delegate to the Exhibition), Alexander Johnston, Esq. (General Manager of the North British Rubber Co., Limited), Arthur Lampard, Esq. (Messrs. Harrisons & Crosfield, Ltd.), Monsieur E. Pollet (Consul-General for Belgium), George Croll, Esq. (Vice-Chairman of the Rubber Growers' Association), Monsieur F. A. Vieira (Consul-General for Brazil). On his left Monsieur Edmond Leplae (Director of Agriculture, Brussels), John McEwan, Esq. (Chairman of the Rubber Growers' Association), London), Señor J. A. Mendes (Delegate for the State of Pará, and for the Commercial Association of Pará, Brazil), Sir William Taylor, K.C.M.G. (Malay States Information Agency), F. Pegler, Esq. (General Manager of the Northern Rubber Co.), Norman W. Grieve, Esq., H. Kerr Rutherford, Esq., Dr. H. Alford Nicholls, C.M.G. (Delegate for Dominica, B.W.I.), the Hon. W. L. McKinstry (Delegate for British Honduras), James A. Anderson, Esq., Jan. G. Anderson, Esq., J. P. Anderson, Esq., C. J. Andrews, Esq., Dr. Jayme de Argollo Ferrao, Jor (Commissioner for Bahia, Brazil), G. M. Ballardie, Esq., I. de C. Ballardie, Esq., O. W. Barrett, Esq. (Director of Agriculture, Philippine Islands), Cyril Baxendale, Esq. (Representative of the Planters' Association of Malaya), A. S. Baxendale, Esq., Noel Bingley, Esq. (President of the Bandjar, Java, Rubber Planters' Association), Miss Edith A. Browne, F.R.G.S., Dr. Theodoro Braga (Delegate for the Government of Para, Brazil), Madame Maria Braga, Colonel R. P. Brazil (Mayor of Itaituba, Brazil, and Delegate to the Exhibition), Dr. Antonio de Souza Castro (Delegate for the State of Para and Municipality of Belem, Brazil), Frank Clement, Esq., Hon. Edward Coke, Arthur Dealtry, Esq., Morland M. Dessau, Esq., A. Oliphant Devitt, Esq., Joseph Dunbar, Esq., Gerald Fitz-Gibbon, Esq., Press Manager for the Exhibition Management), Miss D. Fulton (Secretary of the Exhibition), J. C. Gardner, Esq., C. L. Gatin, D.Sc. (Official

Secretary of the French Government to the Exhibition), Madame C. L. Gatin, Captain H. Gordon, Charles Grenier, Esq. (of *Grenier's Rubber News*, F.M.S.), J. F. de Groot, Esq. (Australia), H. de Courcy Hamilton, Esq., E. L. Hamilton, Esq., Colonel F. W. Hardy, John Hay, Esq., T. G. Hayes, Esq., J. W. Hickson, Esq., (*Ceylon Observer*), Richard Hoffman Esq., Mrs. Hoffman, R. M. Howison, Esq., T. Clifton Hutchings, Esq., (Government Representative of the State of Kelantan, F.M.S.), Edward W. Keith, Esq., H. O. Kennedy, Esq., E. L. Killick, Esq. (Rubber Editor of the *Financier and Bullionist*), R. N. Lyne, Esq. (Director of Agriculture, Ceylon and Government Delegate to the Exhibition), C. O. Macadam, Esq. (Director, Rosehaugh Tea & Rubber Co., Ceylon), Señora J. A. Mendes, H. T. Moore, Esq., H. Eric Muller, Esq., Arthur Murray, Esq., Mrs. Murray, Comtesse da Conceicao Serra Negra (Representative of the State of Saõ Paulo, Brazil), R. G. Newbold, Esq. (Assistant Secretary Rubber Growers' Association, London), Leon Osterrieth, (Commandant, Government Commissioner for the Belgian Section of the Exhibition), Vicomte de Pedralva (Government Commissioner of the Province of Angola, Portuguese West Africa), E. F. Pfaff, Esq. (Representing the *India Rubber World*, New York), Dr. Carlos de Cerqueira Pinto (of Pará, Brazil), E. Playford, Esq., A. C. Radmall, Esq., J. Ritchie Esq., E. Robbins, Esq., F. Crosbie-Roles, Esq. (Managing Editor *Times of Ceylon*), E. G. Salmon, Esq. (Editor of the *Rubber World*), Philip Schidrowitz, Ph.D. (Vice-President of the Fourth International Rubber Congress), Ludwig Schmidt, Esq. (Representing the *Gummi-Zeitung*, Berlin), J. L. Loudon-Shand, Esq., Frank G. Smith, Esq. (Secretary Rubber Growers' Association), T. E. Smith, Esq., H. E. G. Solbe (Delegate of the Planters' Association of Malaya), Frank H. Spaull, Esq., Robert Stewart, Esq., Dr. Joseph Torrey (President of the Fourth International Rubber Congress), Mrs. Torrey, Thorold Waters, Esq. Secretary of the Fourth International Rubber Congress), H. A. Wickham, Esq., J. P. Wileman, Esq. (of Rio de Janeiro, Brazil), Henri Woog, Esq. (of Paris), Leonard Wray, Esq. (Malay States Information Agency), A. Staines Manders, Esq. (Organising Manager of the Rubber Exhibitions).

" THE OFFICIAL REPRESENTATIVES."

After the usual loyal toasts, the first was that of " The official representatives of the countries taking part in the Exhibition."

The CHAIRMAN : Ladies and gentlemen, the toast that I have the very great honour and the very great pleasure of proposing for your acceptance this evening is that of the ladies and gentlemen of the countries taking part in the Exhibition. The toast opens up a wide vista over which we can roam in fancy in contemplation of those great areas which are represented by the delegates we desire to do honour to this evening. The exhaustive official Hand-book of the Exhibition is, I think, the most complete descriptive account in existence at the present moment of the various countries in the tropic and the sub-tropic world. The sixty-six special articles in that book deal with every product almost that is known in those countries, and they leave absolutely nothing to the imagination in their information concerning the successes of the past or the possibilities for the future in those vast regions. (Hear, hear.) But the guide book of the Exhibition, comprehensive as it is in an extraordinary degree, is only a reference to what we find in the Exhibition itself. (Cheers.) When we come to look at it, the whole tropical and sub-tropical future has been summed up there, and a careful inspection of the various Courts is a liberal education for those who have a thirst for knowledge or the money to invest. When we have been through the Belgian Court, through the Brazilian section, and after taking on our road the Netherlands and Queensland exhibits, until we come to the splendid exhibition by la belle France, when we have seen the products of the Sudan, the Malay Peninsula and Ceylon, and have gone on to the exhibits of Portuguese West Africa and the Philippines, we realise the enormous amount of human effort that has been expended in the collection of these products and their preparation not merely for competition but for the information of all those who take an intelligent interest in the world's welfare. The forest, the plain, the jungle and the desert have all been ransacked for their treasures, and we can see in this present Exhibition the history of all these products from the beginning to the end. We can examine the cotton from the seed to the loom, and we wonder at the minute pests that seem so insignificant and at the same time can do so much mischief. We can examine for ourselves the fibres grown in so many parts of the world, so well exemplified in all the grades of beautiful fibres displayed in the Philippines Court. We can touch and test and taste the exhibits of fruits and sugar products from the West Indies and other countries. We can refresh ourselves with a cup of the delicious coffee of Brazil, and we can examine the nuts and oils, the gums and the mineral deposits of West and Central Africa. Now, ladies and gentlemen, we can do all these things, and in themselves they are a most attractive study, but when we have finished with them we have still to remember that the keynote of the Exhibition is rubber. (Hear, hear.) Here we have an absolutely exhaustive exhibition. I think we can see everything connected with rubber, not alone from the side of the planter, through the biscuit and the crêpe and the sheet and the blocks and the scrap and the smoked, not alone that, but thanks to the manufacturers who have come forward, we can follow the rubber still through its various uses. We can begin with the motor tyres and the tubing, we can see the tennis court and the beautiful tiling, and a thousand and one things that are in these days produced from rubber, and we can even see that beautifully furnished room, in which rubber has been employed from the carpet to the ceiling, including the papering and the curtains and the chairs and the tables and the sofa, entirely made of rubber. (Applause.) We can see all these things, I say, and I have looked at them all with never flagging interest, but I am bound to say that of all the objects I have seen produced from rubber by the wit of the inventor the most extraordinary that I have observed, and one that interested me immensely was an imitation mutton bone shank which had been produced in most excellent rubber, and which I hear is largely purchased for young puppy dogs to play with. (Laughter.) Now, ladies and gentlemen, it is one thing collecting this great mass of products, but it is quite another thing preparing and getting these products here and producing them in the various Courts in the Exhibition in such a satisfactory and scientifically arranged manner as to be both instructive and attractive. In looking on those Courts I do not believe that anybody can withhold admiration at the way in which the gentlemen who have been entrusted by the various countries with this important duty have performed their task, nor can I withhold my appreciation and admiration of the fact of what is very rare in exhibitions, that, thanks to the gentlemen who have been entrusted with this work, those official representatives who are here to-night, the Exhibition was absolutely perfect and ready to be opened in every particular at the appointed hour. (Cheers.) Now, ladies and gentlemen, I ask you to raise your glasses with me in the toast I have offered to you, that is the health of the official delegates of the various countries represented in the Exhibition, with a wish not alone for their health, but for the continued progress and prosperity of the countries they have so ably represented here. (Cheers.)

The toast having been honoured, with much enthusiasm, was replied to by Professor Emile Perrot, Commissioner-General of the French Section; Monsieur Edmond Leplae, Director-General of Agriculture, Belgium; and Mr. O. W. Barrett, Director of Agriculture in the Philippine Islands.

Professor PERROT: (Translated from the French). Mr. Chairman, ladies and gentlemen, the Fourth International Rubber Exhibition is drawing to a close, and this, as in the case of the previous Exhibitions, has shown us the great efforts which are everywhere being made to improve production and meet industrial needs. The competition between wild rubber and plantation rubber has during the last few years become more acute, but it is not my intention to predict results. I will only say that in the interests of the growers we must hope that new industries will soon absorb an ever-increasing quantity of rubber. That is our sincerest wish. (Hear, hear.) The committee of this Exhibition and the energetic manager, Mr. Staines Manders, are entitled to the gratitude of all the exhibiting nations, as they have by their efforts made the world realise the progress that has been made in the culture and the preparation of rubber. We gather a wonderful lesson from the exhibits of Ceylon, and Malaya, Brazil, the Belgian Congo, the French Colonies and many other countries, and from the stocks which have been displayed for competition in the galleries of the Agricultural Hall. The management of the Exhibition has, for the first time, considered that the moment was ripe for showing some other tropical products on a large scale, and in the name of the French Colonies which have benefited by this decision, I wish to thank them very sincerely. (Hear, hear.) It is just possible that competition between the various rubbers will eventually have to be limited, as there is a chance of the production exceeding the demand, and it is for this reason that large growers, either private or companies, are now considering whether it is not advisable to devote capital and labour also to the production of various other tropical plants. In the section representing the French Colonies, we are showing some of these tropical agricultural products, which will admit of an economical evolution without the planters having to suffer through any possible crisis due to an over-production of rubber. We are glad of this opportunity of showing that we are in a position to supply all the oils, all the textile products, and also such things as cocoa, coffee, vanilla, essences, and many other products that are largely needed in Europe. But we are not alone in that respect. A visit through the various Courts and stands of the Exhibition has shown that there are many other countries ready to meet the market with these requirements. I am, therefore, awarding no flattery in complimenting the management of the Exhibition on their keen comprehension of the present outlook in tropical production by introducing all tropical products, and in saying this I am sure that all the official representatives of the foreign Governments will agree with me. (Applause.) I should like at this point to call attention to the satisfaction that is felt on all hands by the exhibitors and their representatives. All of us, I am sure, feel convinced of the benefit resulting for them and for their countries, both from the Exhibition itself, and from all the conferences by which it has been possible to exchange ideas and views of the greatest interest. (Hear, hear.) This Exhibition will leave with us, together with its pleasant recollections, a large budget of information which will help every producer and every manufacturer in the great field of business competition. Ladies and gentlemen, I raise my glass to the British Empire, to the greatest Colonial nation of the world, to hospitable England, and I ask you to associate with my wish all the countries represented at this international banquet, our common desire being that the economical struggle shall remain always a pacific struggle. My last thought goes out to the humble assistants of the Europeans in their energy, the natives. They furnish the labour of the tropics, and they should not be forgotten by their employers. Ladies and gentlemen, once more let us raise our glasses for the British nation, the Committee of this Exhibition, and the ever-increasing prosperity of the Colonies. (Applause.)

Monsieur EDMOND LEPLAE : I was asked by the Colonial Minister of Belgium, M. Renkin, to state how much we are indebted to Sir Henry Blake and the Committee of this International Exhibition of Rubber, Fibres, and Tropical Produce. I well remember Mr. Staines Manders coming to Belgium several times last year to tell us of the coming Exhibition, and the pains he took to show us how very useful it was bound to be to all rubber-producing countries. Ladies and gentlemen, there is a fact that is known to all nations, and that is that we know our real friends when we are in trouble. Now, Sir Henry Blake and the Committee of this Exhibition are real friends indeed of all nations, and of all the companies and shareholders interested in the growing of rubber. (Hear, hear.) The nations and the shareholders in the companies were in great trouble when Sir Henry Blake and your Committee very pluckily undertook to organise this wonderful Exhibition, where all of us have learned so much about the great future of the rubber industry and the ways that we should follow to steadily improve the quality and yield of our rubber crops. (Applause.) We also learned to know many new tropical products, the remarkable possibilities of many British and foreign Colonies, and last, but not least, the practical and economical value of the many-sided advertisement that was to be obtained through this Exhibition. (Hear, hear.) What we learned will no doubt be turned to good account for the opening up of new Colonies such as ours. I might assure Sir Henry Blake and your committee that we eagerly look forward to the next Exhibition, and will be ready at their first call to do our share in this highly efficient work. (Cheers.)

Mr. O. W. BARRETT, Director of Agriculture, Philippine Islands : I wish you to know what a special pleasure it is to me to spend to-night here, and to tell you how glad I am to be one of those officially replying to this toast. We in our part of the world have persevered against some very striking difficulties, but we have persevered up to the present with success, and we are not only on the map, but I am pleased to say we are able to take our part well in an Exhibition such as this one. (Hear, hear.) We have all seen Exhibitions, but did you ever see one quite so successful as this one has been ? (Applause.) Run by our most efficient and assiduous managing director and our excellent chairman, could it have been otherwise ? The world will hear of it, for those who have taken part in it will carry good reports to the ends of the earth. I am glad I came ten thousand miles and tried to show you in our own way that there is something to be said for us in our far corner. The Press of the Far East is now waiting for a report on the results of this Exhibition, and I will leave it to you, ladies and gentlemen, to guess—you can tell from that I am an American—to guess what kind of report it will be. (Applause.)

"SUCCESS TO THE RUBBER INDUSTRY."

Mr. **NORMAN W. GRIEVE** proposed "Success to the Rubber Industry," and said: I was rung up on the telephone yesterday by the indefatigable manager of the Exhibition, Mr. Manders, who asked me if I would propose this important toast. My first impression was "There's another good dinner spoilt." (Laughter.) However, I accepted the responsibility, and must say that I feel a great honour has been afforded to me in being entrusted with such an important toast on this occasion. In a measure, as I am a humble unit in the great army of producers, I felt that I would be in a way proposing my own health. Success to the rubber industry means benefit to myself. However, on this occasion it is a much more catholic affair than any mere personal matter, because we have here gentlemen from all parts of the globe who are producers of this article, and also a large body of manufacturers are represented who, while we have brought them the raw products, have used their skill to work up those products for all the uses of humanity. I, therefore, feel it is a wide subject to tackle, and recognise a considerable responsibility in undertaking the task of proposing the toast. I am reminded of a story of the late lamented Corney Grain. It was an election sketch and he was the candidate, and he described how he went down to a dinner in his constituency where all the local people of eminence and others were collected. On that occasion, as at all big dinners in England, there was an "entrée" and the entrée happened to be stewed kidneys. Corney Grain used to say that there was nothing like leather—until you tasted stewed kidneys. I might say now, there is nothing like rubber. The only thing in the least analagous to rubber that I know of is the old steak we used to have in Ceylon in bygone days. It would have been admirable for the covering of tyres, and would have made a splendid substitute for rubber. Those days have passed, and the present conditions in Ceylon, I believe, permit you to have a better steak. However, this staple of rubber is taking a very prominent place in the economy of things. It is not an article of diet yet, but I am told that the rubber room contains almost everything. They even have the bone of a chop. I daresay you will, bye-and-bye, get the chop. (Laughter.) It is a fact that this article in which we are interested is extraordinarily useful in every part of our national life. That has been borne in on us very strongly of late. In the Exhibition we have seen what enormous progress has been made of recent years in every department connected with the use of rubber. (Hear, hear.) I know that all of us here have the feeling that the world cannot use too much of it. While most of us like a drop of whisky, we still have a feeling that it is possible that someone may take too much of it, but we have not got any feeling of that kind in connection with rubber. There is no department of home life in which this article does not touch some point or another, from infancy to old age. You have the infant, not muling and puking as it used to do in its nurse's arms, for have you not got the bottle with its rubber accessories? You go through the various stages until you reach the lean and slippered pantaloon, and even he is able to get along quite comfortably, for he has his rubber-tyred chair to go about in, and he has all manner of other advantages all directly due to the improvement that rubber has made in the world. (Hear, hear.) In the whole seven stages the use of this article is increasing every day. There is nothing on which it is necessary for me to enlarge, for in connection with this Exhibition, which has been so admirably engineered, we have had opportunities of the greatest value of meeting together with a number of manufacturers and of acquiring a great deal of useful knowledge in connection with the preparation of our rubber. We are all sure that this Exhibition has done an enormous amount of good in bringing together the producers and the manufacturers, not only by the establishment of good fellowship, but by a practical interchange of knowledge. (Hear, hear.) We have not come to anything like the end of it. (Applause.) The Rubber Growers' Association are at the present moment blessed with an exceedingly energetic President. (Hear, hear.) I can assure you that there is not only no stone, but there is no tiny pebble left unturned to find out how we can encourage and promote new uses for our article. Only a few days ago we had a most interesting discussion with an eminent road surveyor of a very large district in this great metropolis, and he gave some exceedingly interesting information about the experiment which is being carried out for making roadways out of rubber. He not only told us that, although up to date the experiment was on a very small scale, it was successful as far as it went, but he considered it was highly desirable that we should go on and increase the scope and extent of the experiments, and although he could not say how it was going to turn out eventually, we all feel that it is worth while going on. (Hear, hear.) If only we can produce some surface effective as a road covering, it will not only increase the chances of prosperity of our enterprise, but will be for the benefit of humanity in the whole of the civilised world. I was much struck with what the surveyor said. "Not only do I think it worth while going on," he told us, "but I do think what a boon it is for the world that you should risk a little to produce an article not only to benefit yourselves, but to immeasurably benefit the whole human race. By stopping the noises of large centres, the whole wearied brain of the city will be given its proper chance of rest." (Applause.) I believe it is the intention of the Rubber Growers' Association to go on with its design, and risk something to prove that it is possible to get a practical solution of this question of road surfaces. (Applause.) I am speaking for the purpose of wishing success to the growers and the manufacturers. Of course, we growers are periodically faced by bogeys. Every year or so there is the bogey of over-production, and then there is the synthetic bogey. It is a curious thing that my old and valued friend the artichoke, which I am pleased to meet on this evening's menu, is at present under review. I can only hope that this day twelve months, we will be still enjoying our artichokes in the form of soup, and not experiencing their benefit in the shape of hot water bottles. We have gone through many of these scares, and in a year's time I think we will still be drinking our artichoke soup in comfort. (Laughter.) I give you this toast, coupled with the names of Mr. J. A. Mendes, of Brazil, who will speak for the indigenous rubber producers, Mr. C. Baxendale, who will speak on behalf of plantation rubber, and Messrs. A. Johnston and F. Pegler, who will reply on behalf of the manufacturers.

The toast was enthusiastically honoured.

MR. J. A. MENDES : On behalf of the Delegations of the State of Para, its Chamber of Commerce, and the Municipalities of Belem and Itaituba, I had the honour of meeting you at the first banquet of the Rubber Exhibition, given by the proprietors of the "*Financier and Bullionist*" at the Trocadero Restaurant, where there was a large and distinguished gathering of gentlemen connected with the industry. On this occasion again I have to express our high opinion of your kindness and our sense of gratitude for the British hospitality so markedly extended to us by Sir Henry Blake. I could not very well start these few words without mentioning the name of Mr. Staines Manders, and expressing our sense of his energy and organising ability, qualities which are, if anything, surpassed by his kindness to all of us coming from our distant country of Brazil. (Hear, hear). Gentlemen, now that the vast display of rubber and its allied industries is coming to an end, it is not too much to say that the lesson it has conveyed could not be more impressive, and it has been especially so to us Brazilians, who never realised that such intensive culture of our native tree could be possible in so short a time. As a lesson this Exhibition will have a great influence on our trade. (Applause.) Which of us here does not know the influence that the wild rubber has exerted in the world's advancement during the past fifty years ? There were great days in the history of the rubber trade before this other astounding industry came to open new horizons for the serious manufacture of articles containing caoutchouc. It is only now, that, by the unlimited capital and the enterprise of British commerce, this new branch of the rubber producing industry has been brought into being, and no greater tribute could be passed to the credit of the native industry born in the Amazon Valley. Rubber is of all the staple articles so constantly required by the exigencies of civilisation, that the present position in the industry unfortunately reflects the influence of pernicious factors upsetting the equilibrium of its intrinsic value. While all other articles, commencing with gold and ending with cotton, have their real value regulated by the theory of economic equilibrium, which of us can say the same of rubber, notwithstanding the thorough knowledge of its course either in the producing or in the consuming markets ? All that we know is that the statistic position of this article does not yet warrant such low prices. Is it not true that more rubber was required for consumption than was produced last year ? And yet the cost of the raw product declines. To those, however, who predict the disappearance of wild rubber, all I have to say is that our crop for 1913–1914, against all expectations, was smaller by only 6½ to 6¾ per cent., and this in spite of the incalculable results of adverse conditions in the form of heavy and crippling taxation. No, the Brazilian contribution to the world's rubber will, I am throughly convinced, notwithstanding those prices continue to be gathered and marketed. In conclusion let me express again for the State of Para my hopes of meeting you in the next Rubber and Allied Industries Exhibition in this metropolis, facing an amicable and friendly competition not only in the rubber field, but in other industries native to our soils, which are now being stimulated on the Amazon by the low prices of rubber, and of which my country is really a vast emporium. (Applause.)

MR. BAXENDALE : It is with mixed feelings that I rise to respond to the toast. I am indeed very proud to be connected with this vast industry which, financed mainly by British capital and managed by Britain's sons, has contributed so largely to the comfort and the welfare of mankind. (Cheers.) I can also assure you that I appreciate fully the honour you have done me in coupling the toast of the Industry with my name in order that I may thank you on behalf of my fellow planters. It has been most gratifying to be associated for the fourth time with that organisation to whose ability and enterprise we owe the great success of the Exhibition and the Congress we are celebrating here to-night. But, ladies and gentlemen, I must crave for pardon for introducing a ghost, or should I call it a bogey, to this festive board. Perhaps as Mr. Norman Grieve has already introduced the bogey I should say that I ask you to endure its presence a few moments longer. We are told that the plantation industry is doomed to extinction, and it seems that our only hope lies in the successful and profitable extraction of resin and bark from our trees, these substances being essential to the successful manufacture of synthetic rubber. (Laughter.) The greatest care must be taken to keep them free from any globules of latex, because the inclusion of any natural rubber will be regarded as an adulteration, and reduce the market value of the product. (Laughter.) Our next Exhibition I am told is to be held in 1919. What wonderful changes shall we see five years hence ? Probably we shall fly from our lodgings to the Royal Agricultural Hall, and we would be well advised to follow the synthetic roadway and confidently trust that our fall will be broken by the compounded artichokes from Tipperary. (Loud Laughter.) Instead of the dear old bacon smell we all know and love so well the delicious flavour of the essence of pear drops, limited as it is at present to the immediate vicinity of one stand—I will not mention its name—may permeate the whole building from end to end. (Laughter.) The Exhibition will rival Fuller's shops in popularity with the children, and the refreshment bars will all be converted into synthetic sweet shops. I am getting rather prophetic—(Laughter)—but over the portals of the Rubber Growers' Associations Reception Room I seem to see these lines :

"The R. G. A. Council regret to say
That natural rubber has ceased to pay
Their advice to those who would be wary
Is, plant artichokes in Tipperary." (Laughter.)

A relative of mine—I hope you will excuse these domestic details—has recently engaged a cook whom she describes as a "perfect treasure," I understand that she got this cook from the employment of a revered aunt who was very loth to part with her. She also has a parlour maid who is very far from being a perfect treasure. She is one of those sour-faced long-tongued women who never grace any situation for more than a month. The other day she asked the perfect treasure whether she would like to hear her candid opinion. The cook as a matter of fact is a much younger woman, but the parlourmaid said "You're a damned heirloom handed on from generation to generation." Ladies and gentlemen, I would like to ask you who have been associated with the rubber industry for some time if we have not got a perfect treasure who is handed down from generation to generation, and appears just now and then ? I thank you for proposing this toast, Mr. Grieve, and you ladies and gentlemen, for your reception of it. (Applause.)

Mr. A. Johnston : As one of the representatives of the manufacturers' side of the industry, and as the perpetrator of the rubber room to which Sir Henry Blake has very kindly referred, I must thank you for the very cordial way in which you have accepted the toast of the Rubber Industry. To my mind there can be no doubt as to the incalculable value of the Exhibition and the Congress which have been concurrently running. (Hear, hear.) They have enabled the manufacturing side to confer with the producing side of the industry, and undoubtedly the sympathy and desire to assist which have been generated will produce results which cannot but be for the general good of the industry as a whole. (Hear, hear.) We manufacturers have many difficulties to face. We have technical problems which I venture to say are not equalled in any other manufacturing industry. I think our contact with the producing side of the business has proved to us that the planters have also difficulties and problems equally as grave and brain-rending as our own. (Hear, hear.) At the same time it must always be borne in mind that we manufacturers act as the buffers between the producers and the public. If anything goes wrong with the goods, we have to bear the brunt of it. We sometimes have a feeling that producers do not sufficiently realise how far-reaching are the effects of any slight carelessness in the preparation of their rubber. The time was when plantation shareholders regarded manufacturers as a species of unattractive ogres, who, secure in their fastnesses, refused to buy rubber when it was necessary to buy, in order to keep up their prices and provide them with dividends of 100 or 200 per cent. I think, however, the rubber world is now taking a saner view of the position, and realises that high prices are economically unsound and inimical to the industry as a whole. The worst bogey the manufacturer has to fear is a fall in price, for the value of the manufactured goods falls relatively, and it is not to the interest of the manufacturer to have to write off £100,000 or so every few months, as actually happened at the time of the boom. Whether increased prices would stimulate production is an open question. Undoubtedly if the production at such prices did not permit the production to be at a profit the reaction would be automatic, and the advantage gained would be very quickly wiped out. To my mind there is no doubt that in fifty years from now rubber will be used for purposes to-day undreamed of, and I think we have to look to the enterprising spirit of the Rubber Growers' Association and their officials to afford encouragement to inventors and men of ideas to find the new channels for our industry. (Hear, hear.) The evolution of an idea is not the chief difficulty ; it is the getting it taken up, and the exploitation of it. It is in this direction that the Rubber Growers' Association can do invaluable work. Before concluding I would like to say that I regret to find that many names famous in the manufacturing industry do not appear as exhibitors at this Exhibition. I can only hope that at the next Exhibition those names will be represented. (Hear, hear.) I thank you for the kind way in which you have drunk this toast.

Mr. F. Pegler : When I listened to the eloquent, instructive and witty speech of Mr. Norman Grieve, who proposed this toast, I thought he had his tongue in his cheek in talking about his dinner being spoilt by having to propose a toast. It reminds me of a remark made in connection with a dinner many years ago by Bishop Magee, who was afterwards an archbishop, but was then Bishop of Peterborough. He said he felt " just as though a curate was blaming him." In the matter of making this speech I feel that the gentleman who has spoken before me has cut the ground from under my feet in dealing with rubber manufacture. He has dealt with the position fully and explicitly, and I do not wish to go over the same matters. There is only one thing with respect to that gentleman ; I give him all credit for the rubber room, but I have a bone to pick with him. The bone has been mentioned. He did not make that rubber bone. I made it. (Laughter.) I would not have dragged the bone out on a festive occasion like this only that it has been mentioned by Sir Henry Blake and Mr. Grieve. (Laughter.) Well, there is one thing I have thought of in connection with this Exhibition, in going through it, and it is that the display should be recognised by the educational authorities of such a great city as London as of the greatest value for their purposes. It would be far more valuable from an educational point of view if the children were brought to this Exhibition than if they spent many hours in poring over musty tomes. (Hear, hear.) I noticed that a young friend of mine was immensely interested in the fine display from Nigeria. She was more attracted by the great exhibit of palm oil there than by anything else. I wanted to know what she found so interesting in it, and she answered "Why, father says that is the most necessary thing to have in all business." (Laughter.) Mind you, I do not think the stuff on the Nigerian stand was quite the thing the father was referring to. At any rate I think the rubber trade uses less of that commodity than any other trade that I am acquainted with. The rubber manufacturer is almost singular in striving to make the very best thing at the very lowest price, and in trusting to the honour of the people he does business with to give him the orders. I do not wish to detain you further with this, but I would refer to the Exhibition as an exponent of raw rubber. It is, I think primarily for the furtherance of the interests of the potential rubber. In the first, we only saw the valued old article of Fine Para which still holds its own as the King of Rubbers. Now, plantation is shown in all its beauty, and I must congratulate the planters on the magnificent display before us. All I can say for the manufacturers is that the closer you planters can bring your product to the fine qualities of Fine Hard Para the more fully it will have to be used. We only want an article that we can look upon as always fairly level and equal in quality. We do not want particularly low prices but we want a level of prices. I personally do not mind 2s., 5s. or 8s., but the wild fluctuations we have passed through have hit us manufacturers in a degree I do not think you can properly appreciate. I only hope we can get a fairly level price. Thank you very much for coupling my name with this toast, and I am sure I appreciate it greatly. (Applause.)

"THE INTERNATIONAL RUBBER EXHIBITION, 1914."

MR. ARTHUR LAMPARD: The toast I have the honour to propose for your acceptance is that of "The International Rubber Exhibition, 1914," and I think you will all agree that in asking you to drink this toast I am asking you to drink to the best organised and best equipped and the sturdiest specimen of a rubber exhibition held ever in this country or in any other country of the world. (Cheers.) It is very late in the evening, and I have no intention of detaining you unnecessarily, but I imagine—at all events to me, and I believe to most of you who have looked through the Exhibition,—there are many thoughts which must have been brought home as to the merit of an Exhibition of this description. In the first instance it brings together men of all nationalities, and teaches us that after all when we know one another we are very much alike. (Applause.) It teaches too, that as the brains and the work are not monopolised by any one country, this association that we have the opportunity of taking advantage of means a possibility of an exchange of ideas from which we must inevitably all benefit. (Hear, hear.) Another thought I have found the Exhibition brings to one's mind is that the prosperity of any one country is not in any way a menace to the prosperity of another country, but is on the other hand a great advantage, because no one country can prosper without that prosperity being reflected in a great degree on every other country. (Applause.) On the other hand we know that the adversity of any one country is not the sole possession of that country, for we as business men have all repeated experiences of sharing in the adversities of other countries. We have recent examples in the trouble in Mexico, the trouble in the Balkans and the trouble near at hand in Ireland. All these things have tended to upset confidence, and have reached countries other than those in which the particular disturbance takes place, however distant those countries were apart. The other point that comes to us is the internationality of the present Rubber Exhibition. (Hear, hear.) By the representatives we have seen at the Exhibition and by those here this evening it has taught us that commerce in its internationality has absolutely wiped away all barriers, and undoubtedly it has taught us that we have no separate interests, but only one, and that is the interest of all. (Hear, hear.) I listened with great pleasure to what Mr. Mendes said when he told us that the rivalry between the wild rubber and the plantation rubber could be conducted on absolutely friendly lines, and I am quite sure that is so. We are accustomed to international rivalry in sports. We have recently seen it in polo, in tennis, and at Henley, and we know that in this rivalry, though we may gain in one instance and lose in another, it is the best possible influence that can be brought to bear on us. I think that is also so if we look in the right way at the friendly rivalry that goes on between ours and the other countries. We are not only looking at Brazil or the Congo, but we are looking at our own Colonies in the belief that the requirements can only possibly be met if the cultivation is placed on a scientific basis in order that there shall be a regular and ample supply to cope with what we believe will be the world's future greatly increased demand. (Hear, hear.) I ventured some seven or eight years ago to prophesy that rubber would be as necessary and valuable and as much required by the world as either copper, iron or steel. I am a firm believer that that is so. I believe the holding of this International Rubber Exhibition this year and the previous ones has done very much towards attaining that end, and it is in that belief and the belief in the continued prosperity and the brilliant future which lies before us that I am proposing this toast. While we may have difficulties, while we do not at all say that we have arrived at perfection in manufacture or in production, I do believe that we are not very far distant from that point. (Hear, hear.) We have some big problems to face in the East, but we have had similar problems in other industries, and I have entire belief that all the difficulties will be overcome. As I say, the International Rubber Exhibition this year has done very much to carry on, and promote by the knowledge we have gained from it, the objects we have in view. Therefore, gentlemen, I have the greatest pleasure in giving this toast of the continued prosperity of the International Rubber Exhibition. (Cheers.)

The Chairman : The answering of the toast so very ably proposed by Mr. Lampard I believe requires very little from me, because I cannot help thinking that the Rubber Exhibition speaks for itself. But, ladies and gentlemen, it is a satisfactory thing to feel that after all the trouble taken in arranging for and in getting together this Exhibition the result has been, I think I may assume, satisfactory not only to ourselves at home, but to all those distinguished gentlemen who have come here from other countries to assist us in a friendly competition. (Hear, hear.) One can realise that commerce is the true Federation of the World. (Hear, hear.) Mr. Lampard has spoken of the friendly rivalry that exists in various games, and I feel, and felt when my friend Mr. Mendes was speaking of Brazil and the manner in which Hard Para was sticking to its position, as possibly the captain of a Rugby football team feels when his rival comes into the field. We are glad to find the rival here, because he is a straight good fighter, and we must see who to put to beat him, either as forward or as back. I promise Mr. Mendes that we will some day make his team look to its laurels even with that magnificent Hard Para. I have mentioned all the rubber that we have at the Exhibition to-day, from the scrap to the block, but I have not mentioned the gallant forwards and backs that we have playing for us, and all working towards the improvement of rubber. I think we might put our old friend Mr. Wickham forward, and Mr. Byrne, and I will not leave out Dr. Pinto. Then, gentlemen, in addition to those who use the smoke and the acid, we have also an able gentleman in the French department who cures rubber by the sun alone. With all these working to the end that the best rubber shall be given to the world, I believe that when the time comes we will challenge Mr. Mendes in Brazil. I think that anybody who has seen the Rubber Exhibitions from the first—and I am one of those people, because I have had the happiness of being present at every one of these Exhibitions up to the present,—must feel the enormous strides that have been made in the preparation of rubber. In considering that question I must refer to what I feel is after all as important as the spectacular part of the Exhibition. I think the manufacturers will agree that the International Rubber Congress has borne its full share in any success this Exhibition may bring forward in the future. (Hear, hear.) In speaking of that Congress I must refer to the able work of Dr. Torrey, its chairman, and must congratulate those who read papers on the high standard of ability and importance that was achieved. (Hear, hear.) I have been among those who attended from time to time, and listened to the immensely interesting details of manufacture that were contributed to the discussions by various gentlemen, among those I would mention being Dr. Werner Esch and Dr. Slocum. That Congress will have great and lasting results in the future, One of the results that we have so far derived from it is a realisation that there are too many grades of rubber produced at the present moment, and we ought to look forward to the time when the manufacturer may know the quality of rubber that he is going to deal with before he takes it out of bond. I know perfectly well the difficulties that this presents, because it means possibly the establishment of large central factories in the plantation countries. Knowing as I do a great deal about the rubber plantations of Ceylon, I recognise that there are very many estates that could not send to the central factory. But there is a great deal to strive for, and there is something that will be of much value in the future. (Hear, hear.) I see before me a young friend of mine, a lady who has travelled further in promoting this Exhibition than anyone connected with it, I mean Miss Browne. (Applause.) She is as well-known in Brazil, the Argentine and the Amazon as in the Eastern Colonies or in Java and the other Eastern rubber producing countries. But when I am called upon as President of the Exhibition to answer to the toast so kindly proposed by Mr. Lampard and received by you, of "Success to the International Rubber Exhibition" I confess to you that I feel very much like a Governor who has been placed in charge of a Colony. He is a good figurehead possibly, but has an admirable Council that has really managed the whole business of the country. I may be the President of the Exhibition, but the details of this Exhibition from beginning to end, the working out of the whole matter from the time that it was begun years ago, when the different countries were approached, and all the arrangements that had to be made depended entirely upon Mr. Staines Manders. (Applause.) We all know how ably seconded Mr. Staines Manders has been by his Secretary, Miss D. Fulton. (Applause.) Now ladies and gentlemen, I do not believe that any great undertaking such as this is could have been carried through, without the able work of Mr. Manders, in such a complete and entirely satisfactory manner. It might have been done, but it could not have been better done by any man in existence. (Hear, hear.) This Exhibition owes a great deal of its success at home to the work of the Rubber Growers' Association, who assisted at the beginning, and no one realises more than I do how much can be done by a powerful Association of that kind, who are not merely traders looking forward to getting rid of a product, but are ready to put their backbone into it and risk a great deal for the ideal of the extension of the uses of rubber. (Hear, hear.) I will not detain you any longer, ladies and gentlemen, but can only say on behalf of the practical Council of the Exhibition that I thank you most heartily for your good wishes towards this Exhibition, and I only hope its work will bear ample fruits for you all in the near and the distant future. (Cheers.)

"THE PRESS."

Mr. JOHN MCEWAN: Mr. Chairman, ladies, representatives of the Press, commissioners, planters, merchants, dealers, brokers, manufacturers and consumers. I am not sure whether I have included everyone in that category, but I think the word consumers will include all. In spite of what Messrs. Grieve and Baxendale have said to-night on the subject of artichokes, it will be perfectly obvious to all of you on reference to the menu that you have not escaped being consumers of what some people at any rate seem to consider the rubber of the future. Possibly some internal syntheses are proceeding, but I do not choose to warn the unwary about the artichokes of Tipperary that might not agree with Little Mary. (Laughter.) I hope, at any rate, it may not be so. In a dinner of this kind, at the close of a very interesting Exhibition, there cannot fail to be a note of pathos, and I have detected it in a few of the speeches which have been made to-night. Many of us have been working for a very long time in great expectations, and have looked forward eagerly to this Exhibition, and now it is near its close; inevitably we feel, although a great measure of relief, a certain degree of regret. (Hear, hear.) Professor Perrot expressed that when he was referring to this as the Fourth International Exhibition. For the purposes of my speech I would rather refer to it as the Third, because it is the third in London. I understand there is a game which planters and directors in their moments of leisure play with fifty-two pieces of pasteboard. In connection with it they speak of "a rubber." I might say that Sir Henry Blake and Mr. Manders and Miss Fulton in this Exhibition have certainly played the best game of any up to date and may be said to have won the rubber. (Hear, hear.) The pathos which hangs round the close of anything sometimes hangs round the close of a dinner, and it has for the speaker who comes at the end or near the end various advantages and disadvantages. He has heard the beautiful things he intended to say more beautifully said by others, but he has the advantage of referring to what others have said and making up for the paucity of his own ideas by stealing those of other people. I must say in connection with this, the passing Exhibition, however, that it has been to many of us a matter of very great interest and moment, because it records a certain definite stage in the history of rubber production and in what is really the creation of a new industry. We in the world of plantation rubber are dealing with something which was not in existence last century, and here we are in fourteen years in a very advanced stage of development with our new thing. Many in this room have entirely abandoned other walks of life to devote themselves to that one thing of rubber. We are constantly up against new problems and have to think out and plan out how best to solve them. We have been brought into close contact with each other, and all sections of the rubber world from the producers to the manufacturers and the consumers have had to do their best to make the most of the new circumstances. We have heard about the camaraderie of commerce, and I think this Exhibition may well be described as the Confraternity of Commerce, because we have here round this board to-night and have had in the Royal Agricultural Hall for two weeks the representatives of many different nationalities. (Hear, hear.) Although they have antagonistic interests in details, they have all the common aim of presenting to the public on this side and to the whole world the best they can contribute to the comparatively modern industry of rubber. We have had the advantage in meeting each other of learning a great deal. The producer has learned from the manufacturer how he does all he possibly can to avoid using original rubber by raking up reclaimed and reformed rubber so as to prevent the poor producer from getting the benefit of his energies in supplying the raw material. (Laughter.) We have likewise heard from the manufacturer particulars of the awful pains with which he adulterates his rubber before it goes to the public. I am sure this may help us in our future work. (Laughter.) You may be saying to yourselves that I have forgotten the toast against my name, that of "The Press." I must say the rubber people are very greatly indebted to the Press for many things. But the Press have got the almighty "We," and they can frequently do what Royalty does. We are alternately struck with their marvellous imaginings and rendered dumb by their colossal ignorance. (Laughter.) Now and then a specialist among us produces a brilliant article, and the very next week there is something apparently written by the office boy, completely ignoring what has already been said and taking an entirely different line. What we do want in the modern Press—I always like to try and educate them—is the fine old style of sub-editor with his blue pencil, who would check the exuberant verbosity of the youthful journalist of modern times. The ignorance of modern editors is frequently abysmal. When one comes and asks something that is patently absurd, I say "You are hopeless. You will not visit the Exhibition and see what rubber really means. You are not educated beyond the last Century. I give you up altogether." We can only educate the public through the Press, and unless we can rope in the editors we cannot hope to educate the public through the usual channels. I have been asked to couple the toast with the names of two gentlemen. Well, we made a departure here in a dinner of a commercial character by having ladies present. As Sir Henry Blake has told you, we have one lady here who in her capacity as a journalist has travelled far and wide in the interests of this Exhibition. We have also here Mr. Pfaff, of the American Press, and Dr. Argollo, of the Brazilian Press, and I will be delighted if they will reply. But it is unusual to have a lady representative of the Press not only capable but willing in her own person to make a reply. Miss Edith Browne is here to-night, and I am wishful to hear her tell of places she has seen and travelled through in the interests of rubber. I question whether any man in this room has gone so far as she has done for the good of the industry. She has been to Ceylon, the Federated Malay States, Java, Brazil, the West Indies, the Argentine and many other places. There are many in this room who have during this and previous Exhibitions had the privilege of meeting Miss Browne, and have seen a good deal of her and been able to realise her character, and I am perfectly sure none have been able to rub her the wrong way. (Hear, hear.) In addition to her other distinctions she has the honour of being a Fellow of the Royal Geographical Society, and above all things she is a thoroughly good fellow. (Applause.)

Miss EDITH BROWNE, in responding, said: I speak for the colossally ignorant British Press. (Laughter.) In the course of my travels in South America one of the most arduous tasks with which I had to grapple was the mapping out of my programme. I think you will appreciate that better if I remind you that even travelling by express across the vast area of Brazil takes longer to get from North to South than it would do to get from New York to a Brazilian port or from England to a Brazilian port. Whenever I was consulting railway and steamer time tables, and had lost one steamer and was trying to catch another one, the rule of all my plans was to be home in time for the Press lunch on the day before this Exhibition opened. (Hear, hear.) I managed to arrive on the evening before the Press lunch, and had great pleasure in participating in that delightful function. (Hear, hear.) Mind, had I known that you were going to make me talk to you to-night in this way, I do believe I should have planned my programme, not to arrive on the evening before the Press lunch, but on the morning after the Rubber Banquet. (Laughter.) It is not because I do not appreciate the honour, but speech-making, I thoroughly agree, takes away one's appetite. I believe that, to make amends, there is going to be an international supper for all those who have had to speak to-night. My position is all the more difficult because I recognise that you have every right, after I have travelled so much in South America, and have only just come back, to expect me to speak for at least five minutes without subjecting you to one minute's boredom. But unfortunately—or perhaps fortunately—adventures never come my way. They always dodge me, and that I consider very unkind treatment of a poor journalist. I go to visit a timber area, and the manager says "You should have been here a few days ago. We caught the biggest tiger that ever walked across the compound." I go on a rubber plantation—and, by the way, I may tell one of the gentlemen who has spoken that I have never been on a rubber plantation where any of the planters had time to play Bridge —well, after spending three or four weeks there rising at about four in the morning in order to be in time for roll call at 5 o'clock, and going to bed at 10 o'clock at night so as to be up in the morning, I take my departure. A day or two later I get a letter saying "What a pity you left when you did. Last night we got the biggest snake we have ever seen." I have been in a railway accident and did not know anything about it except that the train stopped and we had a picnic on the side of a precipice. I have been in several earthquakes and have known nothing about them except by the kindness of the Press. On one occasion the earthquake was so magnificently reported by the British Press that I received a cable asking if I was safe. That was the first I heard of the earthquake. (Laughter.) You can hardly expect me, therefore, to entertain you with any adventures, but I take it that I am expected to say a few words seriously about the countries through which I have travelled. When one goes to the South American Republics, on the day of arrival one is ready to write columns and columns of criticism, but day by day one learns to realise that it takes a considerable time before one can venture to pass any criticism whatever. One has to stay there long in order to look at things from the local point of view, and to realise the conditions of national environment, not looking at things with British eyes or trying to balance them with British ideals. There is one statement, however, I think I can make about South America, and that is that South America is undoubtedly the coming continent. Some may say it is already a continent that has come to the fore, but the achievements there, believe me, are infinitesimal in comparison with the possibilities. Let me mention just the one country in which I spent the greater part of my time, the Republic of Brazil. During this Exhibition I have many times been asked whether I will take a bet as to whether Brazil will be represented at the next International Rubber Exhibition. I will take a bet with any of you that Brazil will be represented at the next Rubber Exhibition by rubber, and I place my faith in three Brazilian gentlemen who are in this room to-night, my friends Dr. Argollo, Dr. Pinto, and Mr. Mendes. (Cheers.) I would like to say, while I am on the subject of Brazil, that as far as I understand these Exhibitions, unless I have thoroughly misunderstood them, they are not organised entirely or chiefly for the benefit of plantation rubber. (Hear, hear.) They are organised for the rubber of all countries, and if I may express my humble opinion one of the greatest advantages has been the bringing together of the leading men in the wild rubber and the plantation rubber worlds. (Hear, hear.) I would like to say a word or two to capitalists and investors who would desire to share in the development of South America. My advice is, first of all to go there and see for yourselves, rather than seek guidance from people, many of whom have never themselves set foot in the countries. Do not be alarmed by stories about the climate of these countries. I have spent 10½ months in South America and have not had ten minutes' illness. Another thing is to learn the language of the country. I heard a very nice story in Brazil. It was a very good criticism of my countrymen, and I took it to heart myself. An English Consul had been in Brazil for fifteen years. He was just leaving the country, and his countrymen gave him a dinner. The Consul, in making his speech, told them that as he was really in the bosom of his family he could say what he thought, and this is what he said: "You know, between ourselves, these Brazilians are very stupid. I have been here fifteen years, and there is still not one of them who can speak a word of English. I always need an interpreter." (Prolonged laughter.) And now I just want to say how pleased I am to see so many of my friends round me, people to whom I owe a great debt of gratitude for kindnesses shown to me in the East and the West. For instance, I see Mr. Crosbie Roles, who was very kind to me in Ceylon, and there are several Brazilian gentlemen present to whom I must express my most cordial thanks. But there is one person in this room to whom I wish to express my gratitude and obligation. That is Mr. Staines Manders. Some years ago I burned my boats, and went into the City and walked into various strange offices. This is absolutely the truth. I told everyone I wanted to go abroad and was prepared to take any job. Mr. Manders at that time was one of the strangers I saw. He was one of the two men who started me off on such a happy life that I would not give it up for anything else in the world. (Cheers.) In responding to a toast, the correct thing is entirely to forget the subject of the toast. Possibly you would like to know how I joined the Press. I started my journalistic career early in my teens. I won a prize for a competition essay on "How to win a husband." (Laughter.) Ladies and gentlemen, I think it speaks volumes for the critical ability of the Press that I am still unmarried. (Laughter.) Many things have been said about the Press, but all I can say is that I came into the journalistic world also as a stranger. I had no influence when I came to London, but now among the Press people I have some of my very best friends, and it is one of the proudest moments of my life to have been able to respond to this toast this evening. (Cheers.)

Mr. E. F. Pfaff: Now that Miss Browne has so valiantly defended the Press against the accusations of ignorance which were made against it, you cannot expect very much from me. Three years ago I had the pleasure and perhaps the assurance of speaking under similar conditions. I want now to express the regret of the *India Rubber World* and its distinguished editor, Mr. Henry C. Pearson, that he did not have the privilege of coming here to talk to you to-night in my stead. All I wish to say to you, ladies and gentlemen, is this, that in my humble opinion, after having personally participated in three of these Expositions, and having been at the other by proxy, there is no doubt that this is the best of all of them. We American citizens have a perfectly adequate appreciation of that fact. (Hear, hear.) Outside the fact that the rubber trade should be intensely appreciative of what has been done for it by this Exposition, it would appear to me that the whole world, irrespective of geographical position, should recognise the benefit it has conferred on all tropical production by its constructive and instructive character. (Applause.)

Dr. Argollo: Once more before departing I will say with sorrow that a most insignificant unit of the Brazilian pen-holders' brigade has the opportunity and the honour of addressing some words to you. He only regrets that he does not possess all the secrets of modern English, so that he would be able to express all that he feels in his heart and thinks in his mind. If his heart could burst out and shout you would not hear a single complaint, but only a hymn of greeting and gratitude addressed to all those who have so kindly and willingly helped Brazil to take her part in this most interesting Exhibition at the Royal Agricultural Hall, thus allowing my country to prove once more that nothing can put a stop to her progress and to her growing wealth in all branches of human activity. (Applause.) So let me here address, in the name of the Brazilian Press, my most hearty, friendly and sincere thanks not only to the kind and sympathetic trinity of this undoubtedly successful Exhibition, Mr. Staines Manders, Miss Fulton, and Miss Edith Browne, but also to my friendly colleagues of the Press of Great Britain. Allow me now to speak more especially to the Press of the country I am visiting. Dear colleagues, I say, of late you have heard a great deal about Brazil, and this has been probably to the detriment of my country. I will not attempt to deny that we Brazilians are at this moment facing an economical and financial crisis, but I am not putting aside sincerity and truth when I affirm with the utmost conviction that Brazil will surmount these present difficulties and will go ahead on the road of prosperity with triumphant success. (Applause.) In comparison with the rest of the world we are only about the age of a child, but although we are young we have the tremendous ambition of a grown man. Experience is not a virtue of youth, and at the present moment we are only meeting the unavoidable consequences of a too hasty rush towards progress. After a financial crisis, which was caused by an unreasonable inflation of currency, up came a Government in which there were two men in the right places, Mr. Campos Salles as President, and Mr. Joaquim Martinho as Minister of Finance. Economy became the rule, and in four years Brazil was on her feet again, was rich, commanded credit and wealth, and immediately afterwards we astonished the world. Yellow fever was banished from Rio de Janeiro, and in three years we were found among the most prosperous peoples of South America. The rush towards progress continued; telegraphs, railroads, and posts were established; but more than once were we yet to be deceived. Many a stranger and financial adventurer got rich at our expense. A false idea of prosperity made us forget that the world had not been made in a day. Along came the rubber crisis, and a fall in the price of coffee, and the consequences, which I will not say were happy, of a restriction of our European credit. But we are awake again, and we are now struggling to get ahead and to show the world what Brazil can do. The new Government on 15th November next is going to bring forth a new Brazil, the Brazil of Campos Salles. Ladies and gentlemen, do not fret about us, and, dear colleagues, undertake to make Brazil known as a country with a great and uncommonly wealthy future. (Applause.)

"THE CHAIRMAN."

The remaining toast was that of "The Chairman."

Mr. R. N. LYNE, Director of Agriculture, Ceylon, proposing it, said: I feel particularly honoured in being asked to propose this toast this evening, because I belong to the Government service over which Sir Henry Blake ruled on his latest appointment. I had not the privilege of serving under him, but I share in the esteem and affection with which he is regarded in that great Colony. (Applause.) I should like to add one other reason why I appreciate this honour, and it is that I am the head of a Department which owes its origin to our chairman, who founded the Agricultural Society of Ceylon, which prepared the way for the Department of Agriculture. (Applause.) In the *Journal of Tropical Agriculturists*, which appears every month, the name of Sir Henry Blake appears as the founder of the Society over that of his distinguished successor Sir Henry Buchanan, our Patron, and Sir Hugh Clifford, the present Governor of the Gold Coast and formerly Colonial Secretary of Ceylon, our Vice-President. If, as I believe, the agriculture of Ceylon is destined to play an important part in the progress and development of the rubber industry of the East, Sir Henry Blake will enjoy the undying gratitude of those connected with the industry. But we are principally concerned with our chairman to-night as President of the Exhibition. Our labours have been arduous and perhaps somewhat anxious. That they have been brought to a successful conclusion is due to the great energy and skill of the managing director and his able secretary, Miss Fulton, but Mr. Staines Manders will, I am sure, be the first to acknowledge the debt he is under to the personality of Sir Henry Blake, who more than any other man can command the influence and loyalty of both the West and the East. (Cheers.) I have been asked several times during the last few days whether I am not glad the Exhibition is soon to close and that our labours will be terminated. I have answered "No, we rather enjoy it," and the reason of that is because we have been made to feel at home. That is the feeling I have, and I am quite sure it is shared by all who have carried any responsibility in this Exhibition. (Hear, hear.) Ladies and gentlemen, I feel that I can pay our President no higher compliment than to say that he has made us feel at home. I call upon you to rise and drink the health of Sir Henry Blake, our chairman.

Sir HENRY BLAKE: Ladies and gentlemen, the answer to a toast of this kind is usually perfunctory. I can assure you that in this case it is not so. I thank you, Mr. Lyne, for the kindness with which you have proposed my health. I look back upon the times spent in these various Exhibitions as some of the most interesting and the happiest times of my life, because I am convinced that at each and every one of them I was surrounded by friends. To-night I look forward to the time when, as Mr. Baxendale has told you, possibly people will go to the next Exhibition, wherever it will be, on aeroplanes. We must probably allow a considerable time in order that the roof of the Royal Agricultural Hall may be adjusted to give them a proper place to land upon. When I look to the possibilities of the future I look forward to a time when a man sitting in a rubber room will be able to telephone at midday to his home and say " Oh, by the way, we will be having eighty people along to dinner to-night. Stretch the room." (Laughter.) It is a pleasure and a pain to answer this toast, because, as I have said, for several years now I have been connected with this work in one way or another. I feel that I am saying good-bye. (Cries of " No.") Yes, for probably when the next Exhibition comes it will be necessary to get a younger and more active man. (" No.") Anyway, I never can forget the friendship and good fellowship that I have met with in the various years of these Exhibitions, the old friends of former occasions and the new ones that I have just made. I need hardly tell you how anxiously and deeply I hope that this great rubber industry will not alone expand, but also give larger prices for the investment of capital and larger returns for those who have put money into it. I thank you most heartily not only for this most enjoyable evening but for the many happy days I have spent in the International Rubber Exhibitions. (Cheers.)

The Press View.

TUESDAY, 23RD JUNE.

The Press View of the Exhibition took place on Tuesday, June 23rd, when there was a very large attendance of representatives of the leading British and foreign journals. Much pleasure was expressed at finding the Exhibition already in such a complete state. The President of the Exhibition, Sir Henry Blake, G.C.M.G., occupied the chair at a luncheon which was given to the journalistic representatives, at which also many of the Commissioners to the Exhibition and representative manufacturers and others were present.

The toasts of "The King," and also of "Her Majesty the Queen, Queen Alexandra, and the other members of the Royal Family" having been loyally honoured, the only other toast was that of "The Press."

The CHAIRMAN: The phrase "The Press" is very short, yet when one faces its meaning its immensity is almost crushing. In its entirety it is omnipresent, omniscient, and almost omnipotent, and the mightiest bow before it with trepidation; but in its details we are up against the fact that as there are stars of different magnitude, so there are papers of varying weight, and we establish a working definition of our estimate by assuming that all papers that agree with us are sound leaders of public opinion and all that do not are "rags." (Laughter.) I have had a very long and varied experience of the Press in many countries, and I am its debtor for much sound and wholesome advice, while even where I could not agree I could not refuse my admiration for journalistic imagination and descriptive powers. I can understand the professional triumph of a bright and awakening article. When I was in the Bahamas I harpooned a large shark one day, and killed it, and when I got it ashore I found in its stomach two thighbones of a cow, half a large turtle, a hen, and a copy of the "National Guardian" of the day before. When I opened the paper, almost the first article I found was a pretty strong condemnation of myself. I began to have a new appreciation of the widespread influence of the Press. (Laughter.) Gentlemen, to-day all the world hungers and thirsts for news, and the appetite grows by what it feeds on. The daily appetite of the world's incidents and movements is laid before us each succeeding morning, and we are filled to the brim with heterogeneous impressions that tend to dwarf the power of thought, until at length we grasp at ready-made conclusions to save ourselves the process of thinking them out for ourselves. Therein lies, gentlemen, the overwhelming power of the Press, and herein rests that tremendous weight of responsibility that must be the burden of serious journalists. We read of an earthquake in Borneo involving much human misery, of blizzards in America, of tragic happenings at sea, with languid interest, or study the details of the welter of massacre in Mexico, in China, in the Balkan Peninsula, without a thrill. Our palate for sensation is jaded, and our immediate interest is more tickled by a fashionable wedding or a scandalous divorce case than by the uprising of a people. Yet here to-day, while we eat and drink and are merry, we stand on the very brink of a tragedy that may shake the foundations of this United Kingdom and fill our children's children with sorrow. Here, indeed, rests a fearful responsibility upon the Press, and I do not envy the feelings of those who write blindly from theory and not from observed facts. I will say no more upon this matter, but one realises that the basis of usefulness is close observation. To this aspect of journalism you, gentlemen, are to-day devoting yourselves, and I hope and believe that the various phases of the Exhibition will show you what important strides have been made in the progress of the Rubber Industry, in which so large a capital—I think over 250 millions sterling—is invested; and the other industries to which your attention has been, or will be, directed. The management and exhibitors ask for no more than fair, and I hope appreciative, comment. Your verdict on the Exhibition will reach the uttermost parts of the earth, and will, I believe, show that the rubber and allied industries here represented are on a sound and stable basis. We most heartily welcome you, and desire that you shall have every convenience for the carrying out of your respective duties. (Applause.)

Mr. JOHN McEWAN, Chairman of the Rubber Growers' Association, in supporting the toast, said: I have been asked to speak as representing the producers of plantation rubber. This beautiful and interesting Exhibition is made up from a great variety of representative elements. In sequence they may be referred to as,—the collectors of and dealers in rubber gathered from wild trees—the planters and shareholders who have embarked on cultivation and scientific production—the engineers and others who supply to both of these the machinery and general requirements for their businesses. Then come in those who make the rubber into the immense variety of goods for commercial, domestic and other purposes which we see represented in this building. Last of all come the consumers, whom we hope to see here in large numbers. They little know or appreciate the immense part which rubber now plays in the daily life of man. If we could, by some magical power, remove for a day or even an hour, everything into the composition of which rubber has formed a part, we would produce a paralysis in the manufacturing world, and equally so in the domestic sphere. Machinery could not run without rubber packing. Motor cars and vehicles without rubber tyres are now comparatively few. Literally, from the cradle to the grave we are in constant touch with the article. The infant begins his experience with the teat of his feeding bottle, and the dying rarely pass without the help of modern medical or surgical appliances made of rubber. I have not heard of rubber coffins, but I have been warned that, as a rubber Company Director, I would be wise to have prepared a winding sheet of rubber and asbestos. (Laughter.) Where would the pressman be without his fountain pen, or the Press artist without his eraser? What would an important London journal be like without foreign cables? How could a modern paper be produced without printers' blanket? If the deceased Mr. Shakespeare were to re-visit these shades he might be tempted to revise his "seven ages of man" in something like the following terms:—

"As, first the infant
Sucking and drawing at his rubber teat,
And then the whining schoolboy with his football
The bladder rubber made. And then the lover,
At golf or tennis, played each with rubber balls,
Matching his mistress' game. Then the soldier
Who cycles or motors on his rubber tyres
Even to the cannon's mouth. And then the justice,
In rubber boots and coat with rubber lined,
And so he plays his fish. The sixth age shifts.
Then come the rubber bottles and goloshes
To keep out damp and cold. Last scene of all
That does not even end the rubber story,
Of rubber teeth, of rubber eyes and rubber everything."

—(Laughter and prolonged applause.) To revert to plantation rubber. It's history is but a brief one. Certainly Mr. Wickham brought the seeds out of Brazil as far back as 1876, but it took a quarter of a century after that for the industry to show itself as of material consequence. It took its rise chiefly amongst the tea planters who had, many of them, come to the verge of ruin in proving themselves unwittingly the benefactors of the human race. Tea which in my boyhood cost 4s. to 5s. per pound sells now at 1s. 4d. We hear much of the advanced cost of living; what about its decline? Having entered on a career of public benefaction, the tea planter, now become a rubber planter, has unintentionally brought the price of rubber down to an unheard of level. That the result may not be altogether ruinous, the Rubber Growers' Association have set themselves to find new uses for the product and to try to transfer the trade demand from the older so-called wild rubbers to the plantation sorts. They have found the average manufacturer highly conservative in his methods, and no doubt wisely so, but various members of the Rubber Growers' Association, in order to prove that plantation rubber was equal to Para for most purposes, induced certain manufacturers to make for them Motor Tyres, Rubber Floorings, Hot Water Bottles and other goods, which have proved entirely successful. Now two prominent makers of motor tyres have announced that they are using nothing but plantation rubber in their tyres. The Association has offered various money prizes and medals to stimulate phases of the industry, and it has subsidised new applications in the way of Hospital and Church Flooring. The most novel of those has been the Rubber Tennis Court, and it has now under consideration a plan for pushing rubber as a road surface. A suggestion has been made, in view of the numerous serious collisions at sea that have recently been recorded, that a "collision buffer" of rubber should be fitted to steamers for use during fogs. It is probable that rubber could be applied defensively to war vessels, and I commend to Admiral Sir Percy Scott the invention of something to repel the submarine rather than to talk of "scrapping" our fleet. (Hear, hear.) The producers have heard much of the certain purposes in manufacture for which plantation rubber cannot be used, but it is only recently that they have learned of certain purposes for which no other rubber is fit—high-class goods of such delicate transparency that nothing but the choicest and purest of pale amber coloured plantation can serve. (Hear, hear.) Exhibitions like this are a great help to a new industry. They teach both insiders and outsiders. From the present one we expect a large development of industrial and domestic demand, we expect larger trade for our manufacturers, and an increase in requirements that will improve and steady the market for the crude commodity. (Applause.)

Mr. DERMOT FITZGIBBON: I have been called on to reply on behalf of the London Press to the very kindly remarks which have fallen from the lips of Sir Henry Blake, and to express our thanks for the enthusiasm with which the toast has been received. I shall do so in very few words, but I cannot let the opportunity slip of expressing my admiration of this Exhibition, which is already, in defiance of all known rules in connection with Exhibitions, in such a complete state. (Hear, hear.) Great credit is undoubtedly due to the organising manager, Mr. Staines Manders, and the very able secretary, Miss D. Fulton, for the thoroughness with which they have evidently performed their work down to the smallest detail. On behalf of the English Press I wish the undertaking every success. (Applause.)

Dr. ARGOLLO: It is my very pleasant task to respond on behalf of the Brazilian Press. Since we last met at one of these Exhibitions, the use of rubber has spread like oil on the ocean wave. I am convinced that it will continue to spread, not only because there has been a fall in price, but because every day the scientists, the directors of companies, and other devoted friends of the rubber industry are trying, and trying most successfully, to find new ways and means of increasing the uses of rubber. We all know that Mr. Wickham came over to Brazil and took the seeds of our rubber of Para, and we know that the modern plantations of Ceylon and other countries are thus the direct descendants of our *Hevea* trees of South America. Of course, in taking those seeds Mr. Wickham unknowingly provided the first germs of a future struggle between the produce of the Amazon Valley and plantation rubber, but we Brazilians do not think that he either expected or wished to provoke such a struggle. (Hear, hear.) In any case, Fine Hard Para rubber is still the King of the market. The only point in which it is unable to bear successful comparison with the plantation rubbers is in connection with the cost of collection. In that respect, it may still be that we will be able to overcome the difficulty. It must be remembered that the State of Sao Paulo had to pass through a period of struggle in regard to her coffee. At that time it was suggested that Sao Paulo had been ruined for ever, but she learned her lesson, and took to producing many other articles besides coffee, with the result that Sao Paulo is now one of the richest and most prosperous States in the whole world. (Applause.) I think you will find that the State of Para will profit by the lesson that Sao Paulo has afforded her. All along the Amazonian rivers, in the dense forests there are gardens and plantations appearing which will produce for our country not only a new flood of riches but everything that the rubber gatherer is likely to require for his own use, and which he has previously had to obtain from other countries. There are some people who would tell you that the days of Fine Hard Para are over, that our Para rubber is dead, but they are decidedly mistaken. It should not really be a fight between the two kinds of rubber, those of Brazil and those of the East. They will be the best of friends, and that will help in the prosperity of the industry. (Applause.)

Mr. THEODORE EUGENE SMITH, of *The India Rubber Review*, Akron, U.S.A.: I will not detain you except for a moment to express my thanks on behalf of the rubber Press of America for this toast, and to say what a pleasure it is to me to be here. (Applause.) This Exposition, I may say, again carries success on the face of it, and I think should be most helpful to the whole rubber industry throughout the world. (Applause.)

In the course of the proceedings, the Press representatives were each presented, on behalf of leading rubber companies and manufacturers, with useful souvenirs of the Exhibition. These comprised a rubber hot-water bottle, presented by the Batu Caves Rubber Company; a rubber tobacco pouch, presented by the Straits Rubber Company; a set of rubber combs, presented by the North British Rubber Company, Ltd.; a handsome pocket book, presented by the Continental Caoutchouc and Gutta-Percha Company; Dunlop "V" golf balls, presented by the Dunlop Rubber Company; and an ink eraser compounded with M.R.X., from the Standard Asphalt and Rubber Company.

Dinner of the West India Committee.

Wednesday, July 1st.

Sir **Owen Philipps**, K.C.M.G., presided at the dinner given on Wednesday, July 1st, to the Commissioners for British Guiana, British Honduras, and the British West Indies for the Tropical Products Exhibition, held in conjunction with the Fourth International Rubber Exhibition at the Royal Agricultural Hall.

The guests included Sir Norman Lamont, Bart., Sir Ernest Shackleton, C.V.O., Sir Henry Blake, G.C.M.G., Sir Frederick Hodgson, K.C.M.G., Sir Joseph Godfrey, Dr. H. A. Alford Nicholls, C.M.G., Mr. C. Wilgress Anderson, I.S.O., Mr. H. A. Tempany, B.Sc., Mr. W. N. Sands, the Hon. W. L. McKinstry, Mr. Mewburn Garnett, the Hon. C. Gideon Murray, Mr. R. Rutherford, Mr. Edward R. Davson, Mr. E. A. de Pass, Mr. D. Mackintosh, Mr. Luke M. Hill, M.I.C.E., Mr. Frank Cundall, F.S.A., the Hon. Fred Driver, Mr. S. Wylde Howes, Mr. E. Alford Wallace, Mr. F. I. Scard, F.I.C., Lt.-Colonel J. H. Collens, V.D., Mr. Charles Denny, Mr. William Denny, Mr. H. J. Barrett, Mr. R. L. Forbes, Mr. E. G. Salmon, Mr. Hugh F. Wildy, Mr. T. Rutherford, Mr. G. E. A. Grindle, C.M.G., Mr. E. Paice, Mr. T. G. Sharp, Mr. C. T. Rawlinson, Dr. S. E. Chandler, Mr. R. H. McCarthy, C.M.G., Mr. E. W. F. English, Mr. A. Staines Manders, Mr. Marshall Greig, Mr. A. R. Miles, Mr. William Morrison, Dr. C. A. Moseley, Mr. H. P. C. Melville, Mr. Mervyn Baker, Mr. A. K. Lake, and Mr. Algernon E. Aspinall, Secretary.

After the loyal toasts, the first was one in honour of Sir Ernest Shackleton and his forthcoming expedition, specially proposed by the **Chairman**, who said: Before proceeding to give you the next toast on the regular programme, as this is a very tropical night, and as we have as guest Sir Ernest Shackleton, I am sure it will make you cooler if I propose success to the Imperial Antarctic Expedition, coupled with the name of Sir Ernest. I would like to congratulate Sir Ernest Shackleton that he has recently been given all the money he needs for the purpose of carrying out his new expedition. You will be all interested to hear that the West Indian planters are also anxious to add what they can in helping this expedition. (Hear, hear.) They are going to present Sir Ernest with all the sugar that he will require in the course of his work, and it will be West Indies sugar. (Applause.) The West Indian planters—I hope my teetotal friends will forgive me if I allude to the matter—also propose to present to him all the rum that is likely to be consumed during the three years of the expedition. I am sure that everyone present will wish Sir Ernest Shackleton and those who are going with him all success in the undertaking. I hope they will come back having carried out that expedition with great success and honour and credit to the great British

Empire. I give you "Success to the Imperial Antarctic Expedition, coupled with the name of Sir Ernest Shackleton."

Sir Ernest Shackleton said: Sir Owen Philipps and gentlemen,—I feel that I rather butted in on this dinner, but when I heard that there was one, and was given an invitation at short notice, I seized the chance to come, because I felt it afforded me an opportunity to give my sincerest thanks to the West Indian planters for their generosity in giving us those essential stores. I would like to say something briefly about sugar, not that I know as much about it as you do, but because it has been so important to us on our expeditions. It saved our lives on one occasion, and may do so again. When first this expedition was announced I had hoped that all the requisite money had been arranged for, but later on I was met by disappointment. The money just promised has saved me from getting into debt as I had to do before. When the man who is giving the money heard of the position, he said, "I will give you the money you have borrowed, and you need not get into debt to go on this expedition." Before that I had received gifts in kind, and one of the most important was the promise of the total amount of sugar required by the expedition. When I was offered that I was very gratified, but felt somewhat reticent about stating the supply we required, because to me it seemed a large amount, and I doubted if the people who put the proposition forward realised that sugar is the staple food of the Polar explorer. (Hear, hear.) I went very carefully into the question of sugars. There are all sorts of beer and all sorts of sugars, but there is only one sort of sugar the Polar explorer should take, and that is the cane sugar. I do not base this on my own judgment at all, but went with the permission of the War Office to the Royal Army Medical College and saw Colonel Beveridge, the head, and consulted him. He stated at once the heat-forming values of the various sugars, and the sugar you are giving me has the highest heat-forming value, without any water. (Hear, hear.) To us water is a waste material, for we always have potential water at our feet. What I try to get is the greatest weight and the greatest amount of calorics to the lb. Our ration now, based on large experience, consists chiefly of sugar. Our breakfast ration, for instance, for each man is 3 ounces of lard, 3 ounces of sugar, half an ounce of meat protein and half an ounce of wheat protein. It is difficult to conceive of any person enjoying this, but I think this day next year when I look back to this occasion, and do so not forgetting your hospitality, I would rather be there, taking those rations, than at this dinner to-night, and I am not disparaging the dinner at all. I want to tell you one or two things connected with sugar of which you may not be cognisant. On some days in the South in marching we covered 21 miles in 4½ days, and the temperature was just as low as one ever wants it, we rested every three hours and ate two lumps of sugar, and in five minutes actually we could feel the heat coursing through our veins through the immediate effects of the sugar. The big march that we have to do in the coming expedition is roughly speaking the distance from London to Constantinople, and we hope to do it in about 130 days. I may mention another advantage about sugar in the Antarctic, and that is, that the atmosphere is such that you can pack your lump sugar or crystals into open receptacles without it taking any moisture. Such things are advantages that seem very small when food has not to be carefully guarded. In the matter of food we adopt the motto of a famous colonel, "the best of everything is good enough for us." When we have the best given to us as by the West Indian planters, I can only express my thanks for their generous donation. I would like to add that when you toast the Imperial Antarctic expedition you toast not only myself as leader but my comrades who will equally with me share the dangers and difficulties and trials without their names appearing as mine does, prominent practically all over the world. (Applause.) This must be the case in every expedition, for with the leader lies the praise and with him lies the blame. Nobody in this room to-night knows better than I do how much I owe to the men who went with me last time, some of whom are returning with me this time. It is my privilege and honour as well as my duty to tell you that I would not be ready for another attempt if it had not been for the loyalty they displayed on the last expedition. The confidence you place in us by giving something towards this venture will with God's will be justified, and at any rate we will do our best. (Cheers.)

The CHAIRMAN, in proposing the toast of "The Commissioners," said: This evening I feel there are several gentlemen more competent than I am to propose this toast, but I will specially allude to my friend Sir Henry Blake, chairman of this Tropical Products Exhibition. However, I now have pleasure in giving you the toast of "The Commissioners," coupled with the names of Mr. Anderson, of British Guiana; Mr. McKinstry, of British Honduras; Mr. Tempany, who comes from Antigua, and represents also St. Kitts and Montserrat; Dr. Nicholls, who comes from Dominica, and represents that colony; and Mr. Sands, who comes from St. Vincent, and also represents St. Lucia. Everyone connected with our West Indian Colonies, the oldest Colonies under the Crown, knows those names as those of gentlemen who have for many years taken a keen interest in tropical agriculture. It is gratifying to us in this country that all these West Indian islands, and the two great Colonies of the mainland, British Guiana and British Honduras, are all joined together in order to be represented in this Exhibition. It is carrying out a movement which some of us, and I believe most of us, look to with a considerable amount of interest and hope, and that is the gradual securing of more uniformity throughout the West Indies. Other larger Colonies have found that in the competition of the modern world it is easier to make progress by working more together. It has been so in Australia and in South Africa. Anything such as this Exhibition, where all the West Indian Colonies are working together for the advancement of tropical agriculture, is a step in the direction of uniformity, and shall I risk saying—I say it with diffidence—amalgamation between those Colonies, which I believe if it does come about will be for the benefit of all. (Hear, hear.) The West Indies have great scope for everything connected with the tropics. Everything practically that grows in the tropics will grow in one or other of the West Indian colonies. Therefore I am very pleased that with the assistance of the West Indian Committee, which is always through its able secretary, Mr. Aspinall, indefatigable in its efforts to press forward the interests of the West Indian Colonies in this country, they have provided such excellent representation in this Exhibition of their resources. (Applause.) I hope this Exhibition and the labour that has been devoted to it by the gentlemen whose names I have coupled with the toast, may bear good fruit in the future. (Applause.)

Mr. WILGRESS ANDERSON: Sir Owen Philipps and gentlemen,—On behalf of British Guiana I thank you very much for the manner in which you proposed and toasted the Commissioners. I am very pleased we are here to-night at this Exhibition, and I think the time is opportune for inaugurating a permanent Exhibition Committee for British Guiana in London. I would like to mention that the Permanent Exhibition Committee in British Guiana was inaugurated during the Governorship of Sir Frederic Hodgson, K.C.M.G., whom we have here with us to-night. There is one thing I am very pleased to hear, and that is that Sir Ernest Shackleton is taking West Indies sugar. I hope he will on this occasion give Demerara sugar a trial. (Applause.)

Dr. ALFORD NICHOLLS: I crave your indulgence while I say a few words on behalf of Dominica, the coming island of the West Indies. We have heard that the West Indies are the oldest colonies of the Empire. Now I have reason to believe, from geological evidences, that Dominica is as old as any of the other islands. (Laughter.) But from a commercial or economical standpoint it comes rather low down in the scale, for at the time the other islands were being developed by the brains and the courage of the English people, the Island of Dominica was still in the hands of its cannibal inhabitants. Dominica, as most of you doubtless now know, is, after Antigua, the largest island in the West Indies. The soil is rich and the climate is kindly, and merchants in London have found that out, in addition to those public school men and University men who have gone there and made it their home. A number of young men have gone to Dominica to build their bungalows, and are covering a good deal of the island with thriving plantations, which in a few years will add considerably to the exports. I represent here the permanent Exhibition Committee of Dominica. I have been chairman of the Committee ever since it was established a good many years ago. When established it was an offshoot of the Agricultural Society of the island. After a few years the Government took it over, and it is now a Government Department. I remained its chairman, and have done all I could to bring Dominican products to the notice of other countries in order that a good deal of capital might be poured into the island for its development. The planters needed, in order to bring their products to the notice of the world, something like this Exhibition. You have afforded us an opportunity of displaying the products in a very complete way, and if anyone takes the interest to see the West Indies Court he will be surprised to see the number of exports Dominica is able to bring forward. Not only have you beautiful lime fruit, but a wide range of oils, coffee, and other products. All that is necessary to bring us to our true place in the West Indies is for the merchants in this great city of London to take a proper interest in us. The people are there ready to work, but what we want is the capital, and in another decade Dominica will be on a much higher plane than now. This is the first Exhibition I have had the good fortune to visit. I am very glad I have been present, because I think the experience I have gained will enable me to instruct my Committee so that they can make a far greater display at the next Exhibition. (Applause.) I understand Mr. Staines Manders is here to-night. I am very glad to know there is a Mr. Manders. I was under the impression for some days that he was a kind of glorified Mrs. Harris, he was so difficult to see. (Laughter.) I am glad to hear there really is a Mr. Manders, and I am pleased to say that his work, judging by what I have seen at the Exhibition, is very satisfactory indeed, and I must thank him now on behalf of the island I represent for the opportunity afforded us of being present at this Exhibition. (Applause.)

The Hon. W. L. MCKINSTRY: I will not say more than that I cordially thank you for the very hospitable way in which you have entertained me as representing British Honduras. I do not think there is very much time to go largely into the subject of British Honduras.

Leaving out British Guiana, it is as large as all the West Indies put together, but our population is only about three to the square mile. We want people very badly out there. When I saw the crowds in the streets of London I wished we could get some of the people to come to us. (Applause.)

Mr. H. A. TEMPANY: I have to thank you on behalf of the islands of Antigua, St. Kitts and Montserrat for the very cordial way in which you have received the toast. These three islands are the smallest individual exhibitors in this present Exhibition. Though they are small they are actuated by a keen desire not to be left behind, and although their exhibits do not take up a very large space the possibilities of the islands are well represented. We are intensely patriotic, not only in the wide Imperial sense, but in an intense local patriotism that has been the means of getting us through many difficulties. (Hear, hear.) In bringing our products to the notice of the world we owe a debt to the West Indian Committee and its secretary, Mr. Aspinall, who have always been insistent on the smaller islands showing their best . (Applause.)

Mr. W. N. SANDS: I am sure we appreciate most heartily the very cordial welcome extended to us by the West Indian Committee. And we also deeply appreciate all the help given to us by the Committee in making arrangements for our exhibits, more particularly that given by Mr. Aspinall and his capable staff. It is too early to speak of the results of the Exhibition, but from the inquiries made and the interest in our exhibits I feel confident that the results will be beneficial to the Colony I represent, that of St. Vincent. (Applause.)

Mr. ROBERT RUTHERFORD, in proposing the health of the chairman, said that all knew the great interest Sir Owen Philipps took in the Colonies. (Hear, hear.) Sir Owen was always ready to help the West Indian Committee if it had any special matter to forward. In connection with the project of bringing together the Chambers of Commerce in the West Indies, he had said that he would kindly help by giving the members passages to the seat of the Congress when it was arranged. That was a kindness all would appreciate. (Hear, hear.)

Sir OWEN PHILLIPS: I thank our deputy chairman of the West Indian Committee for the very kind manner in which he has proposed my health. I can only say that always it is a great pleasure to me to help forward the interests of the West Indian Colonies. I realise what those gentlemen who have really studied tropical agriculture have done to help the development of these Colonies. Nothing has been more remarkable in recent years than what has been done in another land, that is the Gold Coast, with cocoa. Even though that territory is competing with the West Indian Colonies, we must admire it for raising in a few years the trade from a few hundred pounds to a million or thereabouts. We all know what my friend Mr. Gideon Murray has done to help cotton growing in St. Vincent, and we know what other Governors have done to help tropical agriculture. I thank you most cordially for the kind way in which you have honoured the toast of my health.

Presentation

TO

Sir Henry A. Blake, G.C.M.G.,

PRESIDENT OF THE INTERNATIONAL RUBBER EXHIBITIONS OF 1908, 1911 AND 1914.

Miss D. Fulton,

ORGANISING SECRETARY,

AND

Mr. A. Staines Manders,

ORGANISING MANAGER.

On Monday the 27th July, the Rubber Growers' Association (Incorporated) London, invited the above named to attend a Meeting of their Council at which there was a very full attendance.

MR. JOHN MCEWAN (the Chairman) said : We have invited Sir Henry Blake, Miss Fulton and Mr. A. Staines Manders to our Council Meeting to-day to ask them to accept from our hands some slight token of remembrance in recognition of their work in connection with the late Exhibition. We all know what Sir Henry Blake has done to assist the Exhibition and to promote the interests of the Rubber Industry. He has given his time ungrudgingly (hear, hear) ; he has not been merely an ornamental head of the great undertaking just completed, but a most active worker, day and night (hear, hear). I think we will make the presentation to the lady first. We have heard Sir Henry Blake say that Miss Fulton is the most capable Secretary he has ever met, and we can endorse that (hear, hear). Most of us have frequently seen the lady, and whether it has been on a matter of business, or to obtain information, she has always been most ready and willing to help everyone seeking her assistance, whether she has been rushed with work or not. (Hear, hear.) I have now much pleasure in asking Miss Fulton to accept on behalf of this Association, a memento of our great appreciation of her work. (Applause.)

Mr. McEwan then handed Miss Fulton a handsome Ceylon sapphire and diamond ring, specially made for her.

The Chairman again rose and said that the next presentation would be to Sir Henry Blake. They had previously presented him with their medal and on this occasion thought they would ask him to accept a record of their appreciation in the form of an address which he, the Chairman, would read.

Illuminated Address.

To Sir Henry Blake, G.C.M.G., F.R.G.S.,

Knight of Justice of the Order of St. John of Jerusalem, etc.

The Rubber Growers' Association (Incorporated) desires to put on record its high appreciation of the services so willingly and freely given by you in furthering the interests of the Rubber Industry in general; and to acknowledge that in your capacity as President of the International Rubber Exhibitions held in London in 1908, 1911 and 1914; and as President of the London Committee of the New York International Rubber Exhibition in 1912, you have so greatly contributed to the success that attended all of these enterprises.

Your continuous association with the endeavour to make known to the community the details regarding one of the most remarkable developments of tropical agriculture in commercial history has aided greatly the efforts of those more directly concerned.

All the actual Exhibitions have owed much to the able, graceful and appropriate manner in which you have presided over the many public functions connected therewith, and the Council of this Association feels that you have placed under a deep debt of gratitude all the various sections of producers, traders, and manufacturers who took part in those functions.

In thanking you for the special services above referred to we have in remembrance your past record as Governor of no less than five Colonies of the Empire and the work you have done so well for the good of the Nation.

We trust that you may long have health and strength to enjoy well earned leisure after so active and highly appreciated a public life.

From The Rubber Growers' Association (Incorporated)

JOHN McEWAN, *Chairman.*

FRANK G. SMITH, *Secretary.*

Explanation of Design.

1st Page. The Title.

The seal is the medal of the Rubber Growers' Association worked in vermilion as a seal.

2nd Page.

The arms of Sir Henry Blake surrounded by the Ribbon and Chain of the Grand Cross of St. Michael and St. George.

3rd Page.

The Badges of the five Colonies of which Sir Henry Blake has been Governor:—The Bahamas, Newfoundland, Hongkong, Jamaica, Ceylon, with the shield of Ireland in the centre to betoken Sir Henry Blake's native country.

4th and 5th Pages. The Address proper.

The design has been worked out in 15th Century Flower Pattern of the Old M.S.S. to betoken the century that saw the great developments in Maritime adventure and the discovery of the New World.

The Panel on Page 4 is that of some young rubber trees growing in Brazil; that on page 5 shows a native tapping a rubber tree in Ceylon—the one, the beginning, the other the maturity and fruition so to speak, while the one gives a connection with the New World and the other with the Old World, the latter being also a delicate compliment to Sir Henry

Blake since it gives a direct connection between the Rubber Industry and the Colony of which he was Governor. The monogram or cipher R.G.A. is worked in on page 4 and the date 1914 on page 5.

Sir Henry Blake feelingly acknowledged the honour the Association had conferred upon him.

The Chairman then called upon Mr. A. Staines Manders to ask him to accept the souvenir they proposed giving him, and in making the presentation he would say that the Council knew how Mr. Manders had worked; he had organised and arranged one of the most artistic and commercial Exhibitions ever held in London, or possibly anywhere else. While we may have done the work in an amateurish way, it would not have been the success. He has organised it in such a manner that no one could have done better. Mr. Manders is the holder of our Gold Medal so we could not give him another; however, while he was at Niagara recently in the interest of the rubber industry something happened to his watch and we wish to replace it. Mr. McEwan then presented a handsome half hunter gold watch with the recipient's monogram on the back and the following inscription inside.

SOUVENIR OF THE RUBBER EXHIBITION, 1914.
FROM THE
RUBBER GROWERS' ASSOCIATION (INCORPORATED) LONDON.

Mr. Manders suitably responded on behalf of Miss Fulton and himself.

Mr. McEwan then rose and said that there was another presentation to be made, and that was their Gold Medal to Captain Commandant Leon Osterrieth. We all know the artistic manner in which he organised and arranged the Belgian Section in 1911 and again in 1914. Mr. Osterrieth has left for Batavia but has deputed Mr. Manders to represent him, and I now have pleasure in handing the Gold Medal to Mr. Manders.

NOTE.—Captain Commandant Leon Osterrieth when on his way to Batavia was recalled from Port Said. He passed through London on his way to Belgium to take command of his Regiment, and Mr. Manders handed the Gold Medal to him at Charing Cross.

The business of the Council was then proceeded with.

Distribution of Awards.

Monday, July 27th.

The final ceremony in connection with the Exhibition was the distribution of the awards, which took place in the Council Chamber of the Rubber Growers' Association (Incorporated) London, on July 27th.

As President of the Exhibition, Sir Henry A. Blake, G.C.M.G., took the chair, and presented the trophies to the various winners.

Sir **Henry Blake**: It is my pleasant duty now to hand over some of the prizes which have been awarded in the competitions at the Exhibition which has so lately been held. That these prizes are to be awarded in this room is, I may say, peculiarly acceptable to me, because, of all the forces which have been brought into play for the purpose of securing the success of the Exhibition so ably carried out under the management of Mr. Staines Manders, no force has been at once so constantly exerted and so efficiently exercised as that which has been used by the Rubber Growers' Association. I have already spoken a few words on this subject, and I wish now to repeat how grateful everybody in connection with the Exhibition has been for the constant and the efficient interest of the Chairman of the Rubber Growers' Association, Mr. McEwan. (Applause.) Day by day and week by week he had interested himself in its success in every branch. He interested himself in obtaining for the Exhibition the honour of its being opened by H.R.H. Prince Arthur of Connaught, and in securing the presence of the Secretary of State for the Colonies, and other very important personages who visited the Exhibition and expressed to me and to others how interesting that Exhibition was to them. Therefore there is no more proper place for the presentation of these prizes than the Council Chamber of the Rubber Growers' Association, for the use of which I wish personally to express acknowledgment and thanks. Now, gentlemen, the prizes that have to be awarded to-day are prizes on, I think, the rubber side of the Exhibition. There are various matters which are not yet quite settled. Such prizes, for instance, as the "Grenier's Rubber News" Trophy, the Diamond Jubilee Trophy, and the Planters Association of Antwerp Trophy cannot yet be decided, because the rubber is being thoroughly tested by manufacturers, and it is not expected that the results will be available for some weeks. That in itself shows the care that is being exercised in really seeing that the prizes to be awarded will have been thoroughly earned and will have been satisfactorily given to the gentlemen or the companies competing. (Hear, hear.) The certificates of awards of the various trophies will be issued by the Exhibition management, and are now in course of preparation and will be forwarded to the successful competitors in due course. I now will ask those whose names have been put forward by the judges for the reception of the various awards to come forward, and in doing so I may say that in connection with the first series of prizes the judges were a Committee of the Rubber Growers' Association; therefore you can understand that all these matters have been dealt with very exhaustively by experts.

The trophies were then handed over to the successful competitors.

Rubber Competitions Awards.

RUBBER GROWERS' ASSOCIATION COMPETITIONS:

COMPETITION No. 1.

For the best commercial samples of Plantation Rubber.

Class I.—CREPE.

Gold Medals ..	THE KINTYRE TEA ESTATES CO., LTD. *2
	THE BALGOWNIE RUBBER ESTATES, LTD. *3
Silver Medal ..	THE INCH KENNETH RUBBER ESTATES, LTD.
Bronze Medal ..	THE UNITED SERDANG (SUMATRA) RUBBER PLANTATIONS, LTD.
Diplomas of Honour ..	THE CAREY UNITED RUBBER CO., LTD.
	THE PATALING RUBBER ESTATES SYNDICATE, LTD.
	THE TRONG RUBBER ESTATES, LTD.
	THE LABU (F.M.S.) RUBBER CO., LTD.

Class II.—SMOKED SHEET.

Gold Medal ..	THE HIGHLANDS AND LOWLANDS PARA RUBBER CO., LTD. *1
Silver Medal ..	THE SEAFIELD RUBBER CO., LTD.
Bronze Medal	THE JUGRA LAND AND RUBBER ESTATES, LTD.
Diplomas ..	THE SELANGOR RIVER RUBBER ESTATE CO., LTD.
	THE CHERSONESE (F.M.S.) ESTATE, LTD.

Class III.—ASSORTED GRADES.

Gold Medal ..	THE HIGHLANDS & LOWLANDS PARA RUBBER CO., LTD. *1
Silver Medal ..	THE KINTYRE TEA ESTATES CO., LTD. *2
Bronze Medals	THE JUGRA ESTATES, LTD.
	THE PATALING RUBBER ESTATES SYNDICATE, LTD.
Diplomas ..	THE BALGOWNIE RUBBER ESTATES, LTD.
	THE LAUDERDALE ESTATE.

MR. JOHN McEWAN'S CUP.

For the best exhibit wherever produced.

MR. R. D. GREENHILL, Manager of Highlands & Lowlands Estate in the Federated Malay States. *1

MR. THOMAS NORTH CHRISTIE'S CUP.

For the best exhibit produced in Ceylon.

MR. J. FARLEY ELFORD, Manager of the Ayr Estate (Kintyre Tea Estates Co., Ltd.) *2

MR. E. L. HAMILTON'S CUP.

For the best exhibit produced in the F.M.S. or Straits Settlements.

MR. P. F. WISE, Manager of Balgownie Estate in the F.M.S. *3

COMPETITION No. 2.

For the best exhibit connected with plantation rubber grown in the Middle East.

Gold Medals .. GOVERNMENT OF CEYLON.
GOVERNMENT OF THE FEDERATED MALAY STATES.
Silver Medal .. HARRISONS & CROSFIELD, LTD.

COMPETITION No. 3.

What is adjudged to be the most valuable improvement connected with the collection or preparation of plantation rubber.

No award made.

COMPETITION No. 4.—MANUFACTURERS' SECTION.

For the three best exhibits of rubber flooring in tile or sheet form.

Gold Medal .. THE NORTH BRITISH RUBBER CO., LTD.
Silver Medal .. THE LEYLAND & BIRMINGHAM RUBBER CO., LTD.
Bronze Medal .. THE NORTHERN RUBBER CO., LTD.

COMPETITION No. 5.

For the best exhibit composed of the greatest variety of articles made from rubber for commercial purposes.

Gold Medal .. THE LEYLAND & BIRMINGHAM RUBBER CO., LTD.

COMPETITION No. 6.

For the discovery and application of such new use for plantation rubber as may be adjudged the most valuable—special consideration being given to the weight of the rubber which such application is likely to consume.

Cash Prize of £50 and Gold Medal } MR. MORLAND M. DESSAU, for application of rubber to road paving.

Rubber Growers' Competitions—*continued.*

COMPETITION FOR RUBBER SOLES FOR BOOTS AND SHOES.

BRONZE MEDAL .. THE ENGLISH RUBBER CO., LTD.

RUBBER TRADE TENNIS TOURNAMENT.

FIRST PRIZE.—Two Silver Cups presented by MR. ARTHUR LAMPARD.

MR. A. A. CRAIGEN.
MR. H. E. MASON.

SECOND PRIZE.—Two Silver Cups presented by the MINCING LANE TEA AND RUBBER SHARE BROKERS' ASSOCIATION.

MR. H. M. E. VON BERG.
MR. A. G. VON BERG.

PRESIDENT'S TROPHY.

Presented by SIR HENRY A. BLAKE, G.C.M.G.

For the most complete general exhibit of manufactured rubber goods.

NORTH BRITISH RUBBER CO., LTD., Castle Mills, Edinburgh.

SPECIAL SILVER BOWL.

Presented by the Exhibition Management.

LEYLAND & BIRMINGHAM RUBBER CO., LTD., 26, Duke Street, Aldgate, E.

The Judges, while not awarding the President's Trophy to this Firm, considered that they should receive some special recognition from the Exhibition Management, who therefore presented a SILVER BOWL.

SPECIAL SILVER CUP.

Presented by the Exhibition Management.

HARBURG & VIENNA RUBBER CO., Ltd., 1–3, Golden Lane, E.C.

The Judges, while not awarding the President's Trophy to this Firm, considered that they should receive some special recognition from the Exhibition Management, who therefore presented a SILVER CUP.

MINCING LANE TEA AND RUBBER SHARE BROKERS' ASSOCIATION.

Prize for the best suggestion for new uses for plantation rubber.

MORLAND M. DESSAU, Constadt Works, Lower Edmonton, N.

"INDIA RUBBER WORLD" (New York).

For the best system of coagulating plantation Hevea.

SILVER CUP ..	DR. CARLOS DE CERQUEIRA PINTO, Para, Brazil.

"INDIA RUBBER JOURNAL" (London) COMPETITIONS.

Best collection of photographs illustrating all departments of Rubber Estate Work.

CASH PRIZE £25	H. F. MACMILLAN, Department of Agriculture, Peradeniya, Ceylon.

Best plan of and Essay on a Rubber Estate Factory.

CASH PRIZE £25	LEONARD SMITH, Kapar, Selangor, F.M.S.

"RUBBER WORLD" (London) COMPETITIONS.

For the best Essay—" What is an ideal Rubber Estate."

SILVER CUP (1st prize)	T. CLIFTON HUTCHINGS, State of Kelantan.
SILVER SALVER .. (2nd Prize)	J. McNICOL, Tasarg Estate, Kuala-Nal, Kelantan.

WEST INDIA COMMITTEE COMPETITION.

For the best sample of rubber from an individual exhibitor from the West Indies.

SILVER CUP ..	HILL'S PLANTATION, British Guiana.

"TROPICAL LIFE" (London) COMPETITION.

Best sample of Ceara Rubber.

GOLD MEDAL ..	COORG COFFEE CO'S. ESTATES, Southern India.

"GUMMIWELT" (Hanover) COMPETITION.

For the best rubber manufacturing machine of German make.

GOLD MEDAL ..	HARBURGER EISEN-UND BRONZEWERKE A-G, Harburg a/Elbe, Germany.

"GUMMI-ZEITUNG (Berlin) COMPETITION.

For the best design for laying out a Factory for the manufacture of Rubber Goods.

SILVER VASE ..	GEORGE GAEBERT (Prakticus) Stein Strasse 3, Ost, Berlin-Lichterfelde, Germany.

SIR HENRY BLAKE: Gentlemen, that closes my duties to-day in connection with the presentation of these various prizes, and I can only assure the gentlemen, not only those who have won the trophies, but also those who have not been so successful on this occasion, that every care has been taken by the judges in the different competitions. I wish now, on behalf of the Exhibition authorities, to tender our thanks for the extreme care they have taken in carrying out their task. I have no doubt their decisions will be received with the utmost respect and confidence by every one connected with the Exhibition. (Applause.)

MR. MCEWAN : I am perfectly certain that those gathered together in this room would be very unwilling to leave it without tendering their hearty thanks to Sir Henry Blake for this last office of many that he has given to the Exhibition. (Hear, hear.) All things must come to an end, and I think we are now at an end of the executive work of the Exhibition. Sir Henry Blake gave much time and thought to it, very cheerfully, and when asked to come here to-day he as cheerfully said he would. I think you will agree with me that it is our duty and pleasure to render to him now a hearty vote of thanks for his services in distributing the prizes. (Applause.)

SIR HENRY BLAKE : Thank you, gentlemen, very much. To-day is the end of a series of very pleasant meetings. I shall always look back to them with the most extreme pleasure, and gratitude to all the gentlemen with whom I have come in contact for the way in which they have managed the various things in connection with the Exhibition and for the entire good nature with which they have treated my shortcomings, whatever they have been. We have all been in the same boat, have worked thoroughly together, and I do not think anyone has caught a crab up to the moment. (Hear, hear.) I perform the last duty in connection with the Exhibition with gratitude to those with whom I have been associated, and a great deal of pleasure in handing the trophies to those who have won them, and also with extreme regret at the end of a most pleasant and instructive time in London. (Applause.)

INTERNATIONAL COTTON, FIBRES, AND OTHER TROPICAL AGRICULTURAL PRODUCTS EXHIBITION, LONDON.

(*24th June to 9th July*, 1914.)

COMPETITIONS FOR COTTON.

PRESIDENT'S TROPHY.

Presented by

PROFESSOR WYNDHAM R. DUNSTAN, C.M.G., LL.D., F.R.S.

For the best sample of any new or improved British-grown Cotton of any description which has been established by the grower within the last ten years on a large scale and has furnished at least three successive crops.

Awarded to

THE AKOLA GOVERNMENT EXPERIMENTAL FARM,
Southern Circle, Nagpur, Central Provinces, India.

For the Akola exhibits of Buri and Rosea, sent by the Deputy Director of Agriculture.

BRITISH COTTON GROWING ASSOCIATION.

(*Incorporated by Royal Charter.*)

In connection with the above Exhibition the British Cotton Growing Association presented a Silver Trophy and three Silver Cups for competition, and the awards have now been made as follows :—

Class A. A Silver Trophy for the best general exhibit of various varieties of cotton shown by any Government Department of Agriculture of any British Colony or Protectorate or of Egypt or the Anglo-Egyptian Sudan, such exhibit to have been grown during 1913 or 1914, on any farm or farms under Government supervision.

Awarded to

THE GOVERNMENT AGRICULTURAL DEPARTMENT OF SOUTHERN NIGERIA.

Very highly commended—THE SUDAN GOVERNMENT AGRICULTURAL DEPARTMENT.

Commended—MR. SHEPHERD, Agricultural Superintendent, St. Kitts, West Indies.

THE GOVERNMENT AGRICULTURAL DEPARTMENT OF NORTHERN NIGERIA.

THE GOVERNMENT AGRICULTURAL DEPARTMENT, PUNJAB, INDIA.

Class B. Three Silver Cups, namely, one each for the West Indies, Nyasaland and the Anglo-Egyptian Sudan, for the best type of cotton grown on any farm or plantation during the years 1913 or 1914.

West Indies: Silver Cup awarded to MR. ALEXANDER SMITH, St. Vincent.

Very highly commended—MRS. HOWES, Montserrat.

Highly commended—MR. SHEPHERD, St. Kitts.

Nyasaland: Silver Cup awarded to A. L. BRUCE'S ESTATES, LTD., for Nyasaland Upland Cotton.

Very highly commended — MR. JAMES DOCKIE, Chirala Estates, for Assili Egyptian Cotton.

Sudan: Silver Cup awarded to MR. C. H. NEVILLE, for American quality cotton.

Very highly commended—SALIM BASHUR, for Assili cotton.

Highly commended—

ABDUL AZIZ YEHIA, for Assili cotton.
GWADWALA HABOOSHA, for Assili cotton.
CAPATO ESTATES, for Affifi cotton.

Commended—MR. GEO. ALEXANDER, for Affifi cotton.

THE KALISYNDIKAT G.m.b.H., BERLIN.

Competition for Cotton, open to the world.

TWO SILVER TROPHIES.

1st and 2nd Prizes—one for the best sample of cotton submitted and the other for the second best.

Note.—The awards for this Competition are not known. The British Cotton Growing Association made awards on certain points, the others were being dealt with by the Judges in Berlin, but the results of their deliberations have not come to hand up to the time of going to press.

THE WEST INDIA COMMITTEE'S COMPETITIONS.

(Other than rubber.)

Awards :

THE WEST INDIA COMMITTEE'S SILVER CUP

For the best comprehensive display of tropical products exhibited by any of the Permanent Exhibition Committees participating.

Awarded to

THE PERMANENT EXHIBITION COMMITTEE OF BRITISH GUIANA.

A SILVER CUP

Offered for the best individual exhibit of any article, or articles of tropical produce.

Awarded to

ST. AROMENT ESTATE, DOMINICA. (DR. H. A. ALFORD NICHOLLS, C.M.G.).

A GOLD MEDAL offered by MR. F. N. MARTINEZ.

Awarded to

THE PERMANENT EXHIBITION COMMITTEE OF ST. VINCENT, for their exhibit of Sea Island Cotton.

"TROPICAL LIFE" (LONDON) COMPETITIONS.

(Other than rubber.)

Best Exhibit of Sisal Hemp.

GOLD MEDAL : ANTONIO R. GUIMARAES & CO.,
Loanda, Province of Angola,
Portuguese West Africa.

Best Sample of Robusta Coffee.

GOLD MEDAL: KLANANG ESTATE,
Banting P.O., Selangor,
Federated Malay States.

Best Sample of Copra.

GOLD MEDAL: KLANANG ESTATE,
Banting P.O., Selangor,
Federated Malay States.

The Best and Most Efficient Sprayer (for Liquids) in Two Sections (ordinary type).

GOLD MEDAL: FOUR OAKS SPRAYING MACHINE CO.,
Four Oaks, near Sutton Coldfield,
Warwickshire.

The Best and Most Efficient Sprayer (for Liquids) Knapsack Type.

GOLD MEDAL: MESSRS. W. WEEKS & SONS, LTD.,
Perseverance Ironworks,
Maidstone, Kent.

Most Efficient Power Sprayer.

GOLD MEDAL: MESSRS. W. WEEKS & SONS, LTD.,
Perseverance Ironworks,
Maidstone, Kent.

"JOURNAL d'AGRICULTURE TROPICALE" (PARIS) COMPETITION.

Open to Makers of Machinery and Appliances throughout the world.

For the best collection of machinery or implements necessary for the cultivation or preparation of Tropical Products; or for the manufacture of the raw products; or labour-saving appliances that would prove of benefit to tropical planters.

GOLD MEDAL: MESSRS. WM. McKINNON & CO., LTD.,
Spring Garden Ironworks,
Aberdeen.

Notice.*

DIAMOND JUBILEE TROPHY COMPETITION.

Presented by

A. STAINES MANDERS, Organising Manager.
MISS D. FULTON, Secretary.

For the best sample of Commercial Rubber.

Open to Planters who are Members of the Planters' Association of Ceylon.

"GRENIER'S RUBBER NEWS" (F.M.S.) COMPETITION.

2 Silver Trophies.

For the best and second best samples of Commercial Rubber taken from bulk shipment and grown in

THE FEDERATED MALAY STATES.
STATE OF JOHORE.
STATE OF KELANTAN.
BORNEO.
STRAITS SETTLEMENTS.
STATE OF KEDAH.
JAVA and SUMATRA.
INDO-CHINA.

ASSOCIATION DES PLANTEURS DE CAOUTCHOUC, ANTWERP, COMPETITION.

SILVER CUP.

For the best sample of Plantation Rubber grown in
THE DUTCH EAST INDIES AND COCHIN-CHINA.

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*The Judges who so kindly undertook to make thorough tests of the large number of samples entered for competition are large manufacturers, but they have been very much hampered in their work on account of the War. The Editors regret not being able to publish the results.

Special Meetings, Functions, etc.

In brief are given particulars of numerous social and other Meetings that were held in conjunction with the Exhibition but which are not fully reported elsewhere. Space will not permit of our giving the names of the many thousands of ladies and gentlemen who were present upon the different occasions.

THE "FINANCIER AND BULLIONIST" LUNCH.

Thursday, 18th June.

The Proprietors of the above-named publication invited the Commissioners and Delegates to the Exhibition to lunch at The Trocadero Restaurant on Thursday, the 18th June. just prior to the opening. By request, Sir Henry A. Blake, G.C.M.G., presided, and proposed the toast of the Delegates to the Exhibition, which was replied to by Mr. R. N. Lyne (Commissioner for Ceylon) and Senor Jose Amando Mendes (representing the State of Para and the Commercial Association of Para, Brazil). Mr. Sydney C. Hunt (Chairman of the Financier and Bullionist, Ltd.) proposed a vote of thanks to the Chairman (Sir Henry A. Blake).

BRAZIL DAY.

Thursday, 25th June.

One would not have thought there could possibly be so many Brazilians in London, but on the above named date Snr. J. Rodrigues Vieira (Commissioner for the Government of Amazonas), Mr. N. H. Witt (Delegate of the Commercial Association of the Amazon), Senor José Amando Mendes, Dr. Souza Castro, Colonel Raymundo P. Brazil, Dr. Theodore Braga, Senor Emilio Martins, Senor Bento Miranda, Senor Jayme Abreu (Official Representatives of the State of Pará), Dr. Edmundo da Fonseca (Commissioner for the State of São Paulo) and Dr. Jayme de Argollo Ferrão, Jor. (Commissioner for the State of Bahia) entertained not only a large number of Brazilians but English and Continental residents who had interests in Brazil, also Delegates from the Legation, Senor Francisco Alves Vieira (Consul General for the Republic of Brazil), etc., etc. The arrangements for the pleasure and comfort of the visitors were well thought of and carried out to the satisfaction of all. Gifts of Brazilian products were handed to each guest and during tea Brazilian preserved fruits were served.

LORD MAYOR AND SHERIFFS VISIT THE EXHIBITION IN STATE.

FRIDAY, 26TH JUNE.

The Right Hon. Sir Thomas Vansittart Bowater, Knt., Lord Mayor of London, with Sheriffs Lieut.-Colonel Sir John Humphrey and Sir Frederic George Painter, accompanied by the Lady Mayoress and Lady Sheriffs, visited the Exhibition in state on the above date, with all of the Official Staff of the Mansion House. The party was received by the President and the members of the Executive and Reception Committees, the same procedure being adopted as on the opening day. His Lordship informed Mr. Manders that he could only spare fifty minutes for the inspection, as he had other calls arranged for after lunch. Evidently the party found the exhibits so interesting that the allotted time was extended by one hour. Visits were made to all Courts and the Lord Mayor was received by the Commissioners and Delegates from each country. On leaving, His Lordship stated that it was the best arranged and most artistic Exhibition he had visited.

MALAY DAY.

FRIDAY, 26TH JUNE.

The Malay States Information Agency, London, held a Reception on Friday, 26th June. Sir William Taylor, K.C.M.G., the London Agent of the Federated Malay States Government, with Mr. F. J. Ballantyne Dykes, Deputy Agent, and Mr. Leonard Wray, I.S.O., received the guests, of which there was a very large number indeed, not only of visitors from British Malaya, but of those in England, and from the Continent and far distant parts who are connected commercially with the trade of that country. The Press was well represented, and special arrangements were made for displays of films throughout the afternoon in the hall adjoining the Reception Room, showing tours through British Malaya. High compliments were bestowed on those responsible, not only on the excellent arrangements for the entertainment of the guests at the Reception, but on the solid, commercial character of the huge exhibits both in the rubber and tropical prducts sections. Great credit is due to Mr. Leonard Wray and Mr. F. J. Ballantyne Dykes on the thoroughly complete and systematic arrangement of the exhibits.

His Excellency José Mendes Ribeiro Norton de Matos, Governor-General of the Province of Angola, Portuguese West Africa, visited the Exhibition and devoted a considerable time to the inspection of the exhibits, expressing great pleasure and satisfaction at the arrangement of the Portuguese West Africa Court.

BELGIAN DAY.

SATURDAY, 27TH JUNE.

Messrs. Ed. Bunge, E. Pollet (Consul General for Belgium in London), J. de Hemptinne, and the Committee of the Belgian Section issued invitations for a Reception on the above named date. In addition to His Excellency the Minister for Belgium in London, Count de Lalaing, hundreds of visitors from Belgium and others interested in that country, including the Commissioners and Delegates from the different exhibiting countries, and a large number of London residents, were present. The attendance of ladies at this smart and exceedingly well arranged function was very flattering. During the afternoon a very instructive Lecture on "The Belgian Congo" was delivered by Professor Edm. Leplae, General Director of the Agricultural Department at the Colonial Office, Brussels. A large number of interesting films were also shown to illustrate the Lecture. The Belgian Court commanded the Main Entrance and the whole of King Edward's Hall and each Section was thronged with visitors during the whole of the afternoon. Very great and unanimous praise was given to Captain Commandant Leon Osterrieth (Official Commissioner for the Government of Belgium), for, while many of the Courts of other countries were very well and compactly arranged, there is no doubt that the Belgian Section was the most scientific and, at the same time, artistic one in the Exhibition. The vast space at their disposal enabled them to carry out the Belgian idea of arrangement to the fullest extent.

Visit to Brighton.

SUNDAY, 28TH JUNE.

Many of the Commissioners to the Exhibition and Delegates to the Congress visited Brighton on the above-named date. A special Pullman train left Victoria Station at 10.15, arriving at Brighton at 11.15. The piers and sea fronts were visited, and at 1 p.m. lunch was provided at the Hotel Metropole and was presided over by Sir Henry A. Blake, G.C.M.G. The afternoon was devoted to motor trips through the surrounding country, and at 7 p.m. dinner was served at the Hotel Metropole, His Worship the Mayor, Alderman Otter, presiding.

In submitting the toast of the evening, "Delegates to the International Rubber Congress," Alderman OTTER observed that they were paying Brighton a flying visit on that occasion, and if it were possible he wished he could clip their wings in order to keep them in the town a little bit longer. They were a body of men strenuously engaged in an important, great and growing industry, and they as men of hard work and energy were given a hearty welcome by frivolous Brighton. He said that advisedly, for everywhere they must have observed frivolity and lightheartedness around them. But Brighton had another aspect which he supposed they had not perceived that day. Brighton had only one industry, and that was the art of attracting visitors. Their business was to entice people, and when they secured their patronage it was generally believed that they not only enjoyed themselves, but went away all the better in health for their visit. (Applause.) Brighton was a cosmopolitan place, and its Mayor got into contact with all sorts and conditions of people who held conferences, congresses and the like in their midst. The representatives of these generally met the Mayor in his parlour and asked the extent to which he could go for their reception. Could the Mayor entertain some 80 or 100 people and give a reception afterwards, and so on. (Laughter.) On the other hand, the delightful feature of their visit was that they gave the Mayor a dinner, which to him was an entirely new and delightful experience. (Loud laughter.) Continuing, the Mayor observed that rubber now entered largely into almost everything in our daily life. Rubber was given that name simply because it was supposed to rub out pencil marks, and not only had it achieved great things, but it would have a far greater influence in the future. (Applause.) He urged that in five years' time, when they would hold another congress, seriously to think of holding it in Brighton, by which time doubtless the town would be paved with rubber. (Loud applause.) The General Manager of the Brighton Railway had said that his Company would electrify the main line between London and Brighton and run a half-hourly service between Brighton and London, and he (the Mayor) supposed that Mr. Forbes would at the same time have to introduce rubber carriages. (Laughter.) On behalf of the Corporation, he thanked them heartily for the honour they had done the town in making the visit and in asking him to attend their pleasant function.

The toast was enthusiastically received and ably acknowledged by several delegates.

Later in the evening Sir HENRY BLAKE proposed the health of the Mayor, stating that most of them would take care to pay Brighton a visit as often as possible.

The MAYOR made a characteristic reply.

The party left Brighton at 10 p.m., arriving at Victoria Station an hour later.

MONDAY, 29TH JUNE.

Her Highness Princess Marie Louise of Schleswig-Holstein, accompanied by Lady Blake and Miss Hawkes (Lady-in-Waiting), visited the Exhibition, and were met by Sir Henry A. Blake, Mr. A. Staines Manders and Miss D. Fulton, and made a tour of the Exhibition. The Delegates from Belgium and France presented Her Highness with bouquets of flowers tied with the national colours of their respective countries. Sir Henry and Lady Blake entertained Her Highness and a party of friends to lunch, after which a further inspection of the exhibits was made, the visit lasting some four hours.

CEYLON DAY.

MONDAY, 29TH JUNE.

The Ceylon Commissioner (Mr. R. N. Lyne), visiting members of the Ceylon Committee and of the working one in London, held a Reception at which between six and seven hundred guests were present. It was truly a "Ceylon Day," for all who are in any way connected with or interested in this wonderful tea, rubber and other agricultural producing country who could get to the Exhibition, were there. While many new faces were to be seen, there were large numbers who had been at previous Exhibitions and who seemed delighted to have an opportunity of renewing acquaintance with visitors from other countries. The arrangements for the Reception were perfect and the Commissioner and Committee were highly complimented on all sides; also on the complete, interesting and instructive Ceylon Pavilion and Court.

FRENCH DAY.

TUESDAY, 30TH JUNE.

Monsieur le Professeur Perrot, Commissionaire des Colonies Francaises, held a Reception on the 30th June, at which the Ambassador for France, His Excellency Paul Cambon, G.C.V.O., was present, also the French Chargé d'Affaires, Monsieur Maurice de Coppet (Consul General for France), Monsieur G. Francois (Assistant Commissioner and Delegate of the Government General of French Occidental Africa, Paris), Monsieur Angoulevent (Governor of the Ivory Coast), Monsieur Fourneau (Governor of the Middle Congo), Monsieur Vergnes (of the French Colonial Administration), Monsieur Fernand Rouget (Assistant Chief of Offices of the Colonial Ministry, Delegate of the General Government of French Equatorial Africa, Paris), Monsieur Andre Cremazy (Commissioner for Indo-China), and a very large gathering of French visitors and residents of London, as well as the Commissioners and Delegates from the various exhibiting countries. The Ambassador made a lengthy visit and inspected in detail the whole of the French Section, which occupied the largest individual space in the building, and also made a tour through the other Courts. His Excellency congratulated Professor Perrot and Dr. C. L. Gatin (Official Secretary of the French Section) on the magnificent display, and on the scientific, compact and complete arrangement of the products. Refreshments were served in the Reception Room of the French Court.

Rubber Growers' Association Reception.

TUESDAY EVENING, 30TH JUNE.

On the above date the Chairman (Mr. John McEwan) and Council of the Rubber Growers' Association (Incorporated), London, held a Reception which was attended by close upon 1,000 guests, who were received at the entrance to the Main Hall by Lady Barlow and Mrs. John McEwan. The Editors would have been pleased to have given a full list of the names of the visitors, had this been possible. It may be mentioned, however, that the guests were not only those associated with the plantation industry, but a large number from different countries of the world, such as the Republics of Brazil, Colombia, Guatemala, from France, Belgium, Germany, United States of America, the Sudan, Egypt, Philippine Islands, Portuguese West Africa, Nigeria, etc., etc., also Shareholders of Tea, Rubber and other Companies, financiers, manufacturers, exporters all more or less interested in Tropical Agriculture.. This was the only evening function directly connected with the Exhibition, with the exception of the West India Committee's Dinner, and while the building was closed to the public, it was kept open for the guests until 12 p.m., and with few exceptions all exhibits were open for the visitors to inspect. Tennis was played on the Rubber Court, and a series of Folk Songs were given. In the main building the Royal Artillery String Band rendered numerous selections. Refreshments were served during the Reception in various parts of the Exhibition, and the Rubber Growers' Section, throughout the whole evening, claimed a continual throng of visitors, for there was on view scenery, specially painted for the occasion, of Rubber Plantations, vast exhibits of plantation rubber entered for competition, a number of rubber trees showing specimens of tapping with different kinds of implements used for that purpose in past and present times. There was also a large display of rubber flooring and street paving, the large and valued collection of Trophies offered for competition, through the kindness of Associations, Companies, Firms and the Press. It may be mentioned, to point out the success of the function and the interest evinced in the Exhibition, that the Inspector of Police called upon Mr. Manders and informed him that the whole of the traffic outside the building was stopped on account of the hundreds of private motor cars arriving, so that the London County Council trams could not pass. A special body of police had had to be called out to regulate the traffic. Further, he added, he had never before seen anything like such a fashionable gathering at the Agricultural Hall in the evening, nor, in the opinion of the Editors, had anyone else, except in the day time during the Rubber, etc., Exhibition. The Rubber Growers' Association, through their Reception, undoubtedly did much to show what a vast industry it was, though small, perhaps, when these lines are written, to what it will be when the Exhibition is next held, whenever that will be.

SÃO PAULO (BRAZIL) DAY.

WEDNESDAY, 1ST JULY.

A Reception was held on the above date and the guests received by Dr. Edmundo da Fonseca (Commissioner for the State of São Paulo, Brazil) and Mme. la Comtesse da Conciecao Serra Negra. It may be termed a social and business gathering, as so many who were present were connected with, or interested in, the State of São Paulo and its great Coffee Industry, visitors from Brazil and residents of London, including Senor Francisco Vieira (Consul General for the Republic of Brazil), as well as the Commissioners and Delegates from the different exhibiting countries. Many novel and interesting features were introduced, national airs rendered by different ladies, and a special cinematograph display with short talk on São Paulo and its Coffee, etc., added to the success of a very pleasant afternoon.

SUDAN DAY.

THURSDAY, 2ND JULY.

The Committee of the Anglo-Egyptian Sudan Government Section held a Reception on the above named date, at which there was a large gathering of those interested in the Sudan and the products raised in that country. The artistic and most completely arranged Exhibit was very much admired and too much praise cannot be given to the Commissioner, Mr. H. P. Hewins, and those who assisted him, for the complete and compact arrangement of the Sudan Court. The site, being in the centre of the building, showed off the display to the best advantage. During the Reception numerous interesting views were shown on the screen and an address on Sudan given by Mr. Wm. Herbert Garrison, F.R.G.S., which was listened to with manifest interest.

Guatemala Reception.

WEDNESDAY, 8TH JULY.

On Wednesday afternoon, Mr. David Bowman, the Guatemalan Commissioner, held an official reception. A number of Commissioners representing their respective Governments at the Exhibition were present, in addition to a large number of those commercially interested in the Republic. Among those present were the Consuls of Argentina, Colombia, Commendador Signor Millelire, late Italian Minister in Guatemala, as well as several ladies and gentlemen of Guatemala, including Señores Pinto (h) Humberto Reyna Barrios, Saenz, etc.

After the Exhibits had been carefully examined, the party adjourned for refreshments. The commissioner presided and welcomed the visitors on behalf of President Cabrera, to whose initiative and continued interest in the welfare of the republic, was due the fact that the country was represented at the Exhibition. It was, Mr. Bowman said, an auspicious occasion. It was the first time that the Government of Guatemala had provided such an object lesson to the traders of Great Britain. The Exhibit, important as it was, was not exhaustive. Sugar—the banana culture—the mineral resources of the country—tobacco growing—the wonderful and extensive forests—all these were unrepresented. But more than enough was exhibited to give very tangible expression to the fact that the resources of the country, many of them, at present, undeveloped—were only waiting the modern magician, the capitalist, who with his enterprise and commercial instinct would transform them into fields of Eldorado. He would not detain them with a long address, but he felt it would be ungrateful not to express his sincere thanks for the kind assistance and encouragement he had received from all sides. In this connection, he might mention that Guatemala was specially indebted to Mr. José P. Ugarté, a gentleman who had recently visited Guatemala and who was at all times ready and anxious to place his knowledge of the country at the disposal of any of those who might desire it. He was sure that they would all like to hear Mr. Ugarté's opinion on the prospects in Guatemala. (Hear, hear.)

Mr. J. P. Ugarté, in response to Mr. Bowman's invitation, dwelt upon the immense resources of the country, particularly in respect to timber and the Corozo nuts which would develop into great industries. He warmly supported Mr. Bowman in his views with regard to many other industries which it had been found impossible to represent at the Exhibition—such as palm oil, sugar and rice. Being in a position to speak quite unofficially and impartially, he fully endorsed everything Mr. Bowman had said.

He then referred in eulogistic terms to the manner in which Mr. Bowman had organised the exhibit and proposed that a hearty vote of thanks should be accorded him. This was carried with acclamation and the proceedings shortly after terminated.

Presentation to Miss D. Fulton.

WEDNESDAY, 8TH JULY.

A large number of delegates and exhibitors was represented on the occasion of the presentation to Miss Fulton, Secretary of the Exhibition, of a handsome three stone blue white diamond and platinum ring as a mark of their respect, esteem and appreciation of her work in connection with it. The presentation was made on their behalf by Dr. Jayme de Argollo, Jr., Sir Henry A. Blake, G.C.M.G., presiding.

Dr. ARGOLLO said: Sometimes one sows seeds, but only useless weeds and sharp thorns appear. Too often great devotedness meets with mere ingratitude. Happily it is not so in the present case. Here, at this great Exhibition, the wonderful initiative energy of Miss Fulton, her self-sacrificing devotion and her attachment to a cause of such international importance must not be passed over in silence. (Hear, hear.) Everyone has noticed her indomitable activity and great zeal as she flitted here and there and everywhere like a sweet fairy queen inspiring everyone with admiration and respect. It is not astonishing, therefore, if some of those who have watched her work desired to co-operate and do in a small way what it is well known that everyone taking part in the Exhibition would have liked to do in a large way. (Hear, hear.) Miss Fulton, I am but the echo of the small committee, and of many others who were too late to take part in this pleasant meeting, and also of all those who daily met the "rubber fairy queen." They desire to give you a slight token of their admiration and gratitude and love. I will now, therefore, on behalf of those we represent, ask Dr. Pinto to appear for once as Cupid and shoot his little bow straight into your heart, and shoot a little diamond ring straight on to your finger. May you wear this ring through long years of happiness and prosperity, and any time you gaze upon it, may you think of those who are present here to day, and of the absent ones who could not come. (Applause.)

Miss FULTON: I cannot say more than that I thank you all very much for showing such appreciation of whatever little I have done. At the same time I want to say that there is but one head and one brain behind everything that has combined to make for the success of this Exhibition. It is not mine, but that of Mr. Manders. I shall always wear this ring with a thrill of kind remembrance of those who have been so kind to me during this Exhibition. (Applause.)

Presentation to Mr. A. Staines Manders.

The President and Commissioners of the French Section entertained Mr. A. Staines Manders to dinner at the Café Royal, on Monday, 29th June, and presented him with a very handsome Gold Medal.

From delegates and exhibitors Miss D. Fulton and Mr. Manders received several presentations, such as a silver jewel box, gold jewelled hand-bag, diamond scarf pins, cigarette case, etc.

Rubber Companies.

During the Exhibition the following Rubber Companies held Receptions, at which there were very large attendances. Those who found it impossible to be present on the exact date of the different Receptions were permitted to use their invitations on any other day the Exhibition was open, and the Management are pleased to say that the invitations issued by the Companies were taken full advantage of.

The Directors of The Batu Caves Rubber Company, Ltd.
do. The Mahawale Rubber & Tea Company, Ltd.
do. The Pelmadulla Rubber Company, Ltd.
do. The Seafield Rubber Co., Ltd.
do. The Ceylon & Eastern Agency, Ltd.
do. The Straits Rubber Co., Ltd.
do. The Penang Rubber Estates, Ltd.
do. The Rubana Rubber Estates, Ltd.
do. The Tali Ayer Rubber Estates, Ltd.
do. The Bagan Serai Company, Ltd.
do. The Batak Rabit Rubber Estate, Ltd.
do. The Glenshiel Rubber Estates Company, Ltd.
do. The Kurau Rubber Estate, Ltd.
do. The Merchiston Rubber Estates, Ltd.
do. The Orient Trust, Ltd.
do. The Pindenioya Rubber & Tea Estates, Ltd.
do. The Dalkeith Rubber Estates, Ltd.

Four Oaks Sprayers secured "Tropical Life" Gold Medal, International Rubber Exhibition, London, 1914.

FOUR OAKS Gold Medal Sprayers, Powder Distributors and White Ant Fumigators

REGISTERED TRADE MARK
THE FOUR OAKS.

WITHOUT THIS TRADE MARK MACHINES ARE NOT GENUINE.

are acknowledged by Plantation Managers all the world over to be the most reliable, efficient, and **THE BEST** and **BRITISH MADE THROUGHOUT.**

This is the well-known **Gold Medal Knapsack Sprayer No. 101.**

In use in thousands of Plantations all the world over.

No. 101. "Four Oaks" Gold Medal Knapsack Sprayer.

Special Features. Entire absence of Rubber Valves. All working parts outside.

FOUR OAKS PNEUMATIC OR COMPRESSED AIR SPRAYER.

"Kent" Pattern.

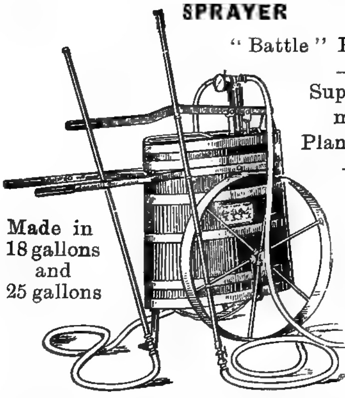
Special Features.
Both Hands Free.
No Continuous Pumping.
Self-contained Pump.

Made in numerous sizes. 1 gallon, 1¼ gallons, 2½ gallons and 4 gallons, &c.

Supplied in Copper and also "Forex" Brass Alloy to withstand the action of Lime Sulphur, Liver of Sulphur, &c.

"FOUR OAKS" VERY POWERFUL SPRAYER

"Battle" Pattern.



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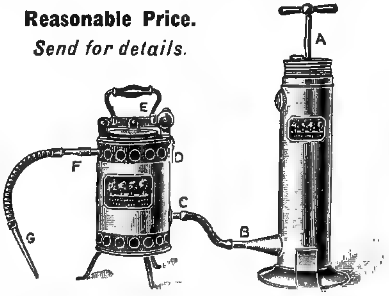

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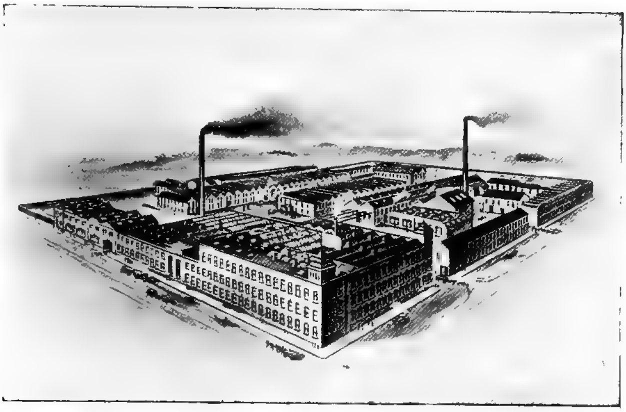

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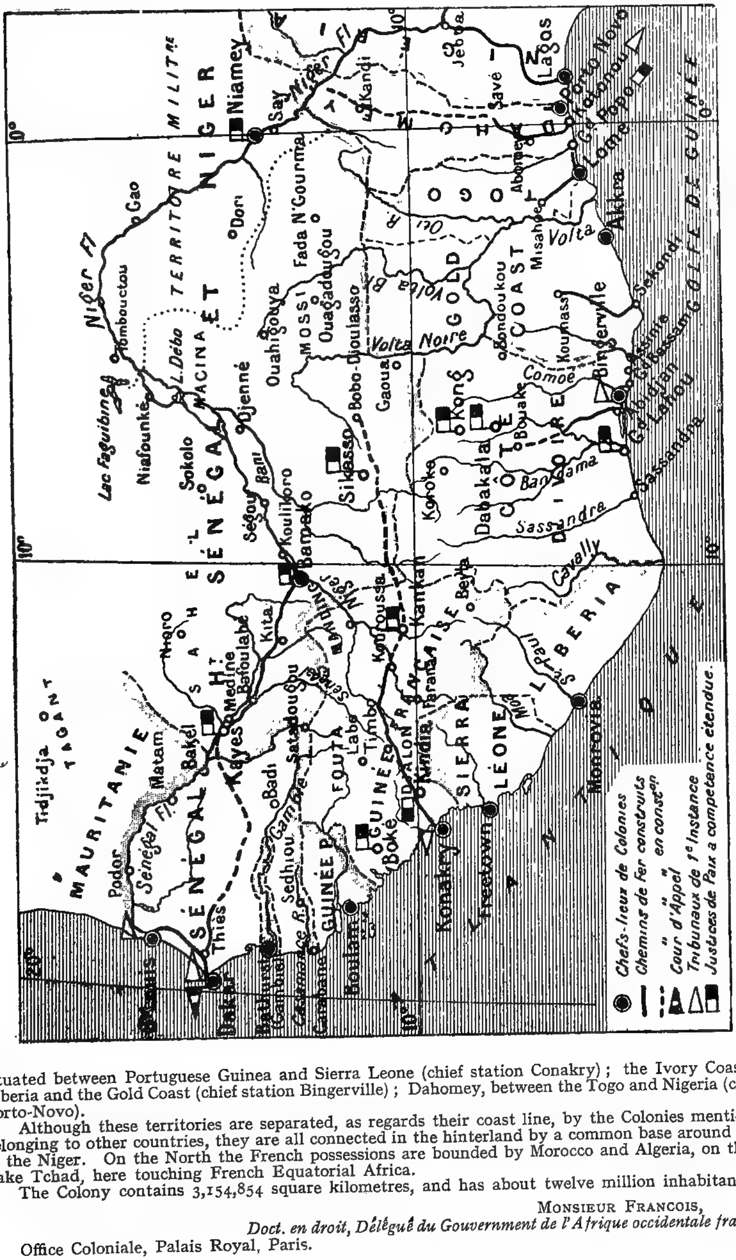
FRENCH OCCIDENTAL AFRICA.

GEOGRAPHICAL SITUATION.

French Occidental Africa is the union under one general Government of all the Colonies which France possesses on the West Coast of Africa, between the Rio de Oro on the North and the English Colony of Nigeria on the South. These may be enumerated as follows :—Senegal and its dependencies—the region of the Casamance is by the side of the English territory of Gambia. South of the Casamance is Portuguese Guinea. The Senegal, therefore, is separated from French Guinea by the region of Gambia and again by Portuguese Guinea—(chief town Saint Louis) ; the territory of Mauretania ; the Upper-Senegal-Niger (chief station Koulouba, near Bamako) ; the territory of the Niger (chief town Zinder) ; French Guinea,



MAP OF FRENCH OCCIDENTAL AFRICA.

Cl. Larose.

situated between Portuguese Guinea and Sierra Leone (chief station Conakry) ; the Ivory Coast, between Liberia and the Gold Coast (chief station Bingerville) ; Dahomey, between the Togo and Nigeria (chief station Porto-Novo).

Although these territories are separated, as regards their coast line, by the Colonies mentioned above belonging to other countries, they are all connected in the hinterland by a common base around the mouths of the Niger. On the North the French possessions are bounded by Morocco and Algeria, on the West by Lake Tchad, here touching French Equatorial Africa.

The Colony contains 3,154,854 square kilometres, and has about twelve million inhabitants.

Monsieur Francois,
Doct. en droit, Délégué du Gouvernment de l'Afrique occidentale francaise,
Office Coloniale, Palais Royal, Paris.

Sanitary Conditions at Para, Brazil.

BRAZIL, unfortunately, has had some ill-natured critics. A new land, many thousands of miles distant from the old world, it would be only natural that from the imperfect knowledge of conditions existing there, and its people, and even of its geography, criticism should not favour the country, but to condemn without reason is an injustice.

However, those who know our country have never borne us any ill-will, from Martius Agassiz and Humboldt, in the past, to Roosevelt at the present time.

Who speak the truth? Those who judge us without knowing us, or those who, knowing us *de visu*, praise us?

The answer is easy.

The Amazonia, that is, the two great Northern States of Para and Amazonas which the ocean-river unites, and the same high aims push on to the same brilliant destiny, has been the principal sufferer of these adverse criticisms. One might say that a blow has been aimed at our very heart in consequence.

Against this campaign a reaction of patriotism was to be expected, and when I was invested with the honour of representing Pará and the Municipality of Belem at the International Exhibition of Rubber and other Tropical Products, in the grand Metropolis of the highest civilisation and justice, the occasion seemed propitious to fight for the truth, to vindicate my State, and to show what it possesses as to climate and sanitary conditions.

I trust my attitude on this subject will not be considered inadequate in connection with an exhibition purely commercial, for on a healthy climate depends, to a great extent, the commercial prosperity of a country.

I believe that all will agree with me that there exists the closest of bonds between economical principles and the successful solving of problems relating to these questions of hygiene and consequent prophylaxis.

As a matter of fact, Life is Capital itself!

To this factor all our care is due and all our sacrifices. Such is the motto of our present Government, which, full of wisdom and patriotism, is slowly and successfully putting into practice all the greatest sanitary measures in its power.

My position as a medical man, with 14 years' practice in Pará, authorises me to discuss its climate and sanitary conditions, and to give gladly to those who wish, minute and truthful information on this subject.

The State of Pará, situated in full equatorial region, has necessarily a hot climate.

The heat, however, is softened by several meteorological factors, such as the frequent rainfall, the trade, winds, the great mass of water from the estuaries of the vast rivers, such as the Amazon and the Tocantins and the wonderful tropical forest rich in vegetation, where deserts and arid tracts of land are unknown.

In consequence, the heat is perfectly bearable, and the delicious coolness of the mornings and the evenings of Pará is quite proverbial.

The high temperature of European summers is exceptional in Pará, where no case of sunstroke, either in a foreigner or a native, has ever been known.

Life there is lived in the open; the dwellings are always accessible to air and to the sun that cheers us from 6 a.m. to 6 p.m.

A close atmosphere is unknown, either in private houses or schools, theatres, cafés, and so forth. Draughts are not dreaded. The poor do not suffer cold, the pauper is not frozen to death.

No frost ruins the farmer, no snow fills our streets with slush. From January to December invariably at 6 a.m. we welcome the rising sun, and invariably at 6 p.m. we see it disappear on the horizon.

Why, then, calumniate a climate that permits life to be lived as it should be lived all the year round, in close contact with nature? What ill-effects can such a climate have on the human constitution? I see none!

But what of the so-called tropical anæmia? you may say. That is merely a myth of the past. And the so-called excessive perspiration? That is rather a benefit than an evil, for to perspire means to eliminate, and this function of the skin means to disintoxicate, which is a good thing. Hence, the elimination through the skin is to alleviate the kidneys—the emunctory that exerts a most important function in the economy of life. Climate is the main factor against all diseases; if it helps to propagate some, it prevents others, and though some are peculiar to it, I am happy to say there are at present no diseases of an epidemic character peculiar to our climate which can endanger the lives of either foreigners or natives.

We had in the past, it is true, one of the most deadly scourges which cost us many precious lives, stopped our progress, and brought discredit upon our country, earning it the name of the land of death, and this in spite of our Black Gold, which was then indeed gold. I refer, of course, to the Yellow Fever of baneful memory.

The yellow fever left Pará three years ago, and left it for ever!

Shown on the Pará Stand at the Rubber Exhibition was a simple authentic document whose silent lines, traced by a clever draughtsman, proved a great deal in favour of humanity. I took it over with me with the tenderness and veneration usually given to sacred things and I was happy to be able to show something worthy of the Government of Pará and the skill of one of my ablest countrymen, Dr. Oswaldo Cruz!

In reading that diagram one could judge what the yellow fever was in Belem, and see that, after six months of hard work, the fever disappeared completely. Still it could not be considered to be eradicated. It was necessary that 178 days (which is the duration of life of a stegomya-fasciata virulenta) should pass without the notification of a new case.

Again, that same diagram demonstrated that by a superhuman effort the epidemic was extinguished, but there remained a few isolated cases, before the fever was officially declared as eradicated on October 16, of 1911, that is, 178 days after the notification of the last case.

The sanitary authorities, however, were not satisfied that the epidemic had disappeared, but believed it might return if strong precautionary measures were not taken. With that intention, a well-organised service of defensive prophylaxis was started, and has never been relaxed.

That no case of the dreaded fever has again been notified is sure proof of the efficacy of the measures taken.

The fear, then, of yellow fever, in Pará must be quite put aside.

The special prophylaxis of yellow fever is a positive scientific conquest, and its wonderful effects have been confirmed everywhere where it has been properly used, as in our State.

Masters as we are of our technique, acquired by a long practice, ready for any emergency, watchful and resolute, we may give the assurance that the yellow fever will never again make its appearance in the State of Pará.

One more circumstance allows me safely to make this assertion, and that is the extinction of a strong neighbouring focus which was to us a constant menace. I refer to the State of Amazonas to-day, also quite free from the terrible scourge.

With this last conquest, the extreme north of Brazil is now, one may say, perfectly healthy.

Now, and only now, are the gates of the Amazonian region truly open to civilisation.

New horizons are accessible to us, and a new world, à l'Américaine, for such shall be the Amazonia of to-morrow in the authorised and valuable opinion of that eminent statesman and thinker, Roosevelt.

Of a less serious character as a tropical disease is the malaria, endemic only in some regions of the State.

Frequent in low marshy grounds, it is rare in the higher and dry land, and very rare on its vast coast, constantly swept by sea breezes which disperse mosquitoes, the carriers of the evil.

Generally speaking, we may say the malaria decreases every day.

As man conquers land and there establishes his home, the malaria disappears, for the anopheles, the fever vehicle, is unsociable, it prefers the solitary woods to the abode of man. That is why it is said malaria avoids civilisation : that is why also malaria is not frequently heard of in the large tropical towns like Belem capital of Pará, where the cases brought to our notice come from the interior of the State. Contrary to yellow fever, which has no efficacious treatment, malaria has its specific remedy in the salts of quinine, of a sure effect always. Only those who will not take this precious drug die of malaria. In Pará, it is distributed gratis by the sanitary inspectors to any who apply for it.

Besides the specific prophylaxis that quinine is, as simple as efficacious, it is of easy individual use. The knowledge of how to use quinine, as well as a general notion of the habits of the anopheles, enables anyone to prevent malaria.

The Government of the State, in order to solve the most important sanitary problem, that of the complete extinction of malaria, has this year started a systematised and well-equipped work of prophylaxis.

Although this work has just begun, I am happy to say that in a short time this *desideratum* will be an accomplished fact.

This plan of campaign against malaria is principally intended as an economical defence to our principal product of exportation—rubber. This tree has, as you all know, its preferable habitat in marshy grounds which are, so far in the majority, explored lands. This campaign does not refer to the whole State of Pará, for surely, two-thirds of its land are high lands (terra firma), well drained and where, in the neighbourhood of the grand tropical forests, rich with the most precious flora, not speaking of the various species of the Hevea, some cities and villages sprang up here and there, which, as the result of the salubrious climate, do not need these sanitary measures.

It is then proved that malaria in Pará is not what it is represented to be by gross exaggeration or by ignorance.

There is a current opinion that a disease exists under the name of beri-beri, with the classic symptomatology of the toxical polynevritis. They say that this morbus is acclimatised in the Amazonia, and breaks out occasionally as an epidemic.

Nothing is more untrue, nothing more erroneous.

During the 14 years of my medical practice in Pará, I have never seen one case that could be diagnosed as beri-beri.

If beri-beri ever existed, it does so no longer. This assertion would not perhaps be worth much had it not been helped by the observations of other medical men in Para.

There cases of polynevritis exist, as everywhere else, from alcohol, from malaria, from feeding causes, etc., but none of them are epidemic.

This does not apply to beri-beri, which must be considered a disease by itself in its nosology, and perfectly described as an infectious specific polynevrite, which agent, however, is still unknown.

This soi-disant beri-beri, I may say, does not exist amongst us. Where, then, is it to be found ? Does it really exist or is it something similar to tropical anæmia ?

There is a tendency to deny its existence, and this theory is the one generally followed by the Brazilian medical school.

This is not the moment to discuss the basis of such a doctrine. My purpose is to remove a fallacy, that of stating us to be the victims of a great epidemic evil, of whose existence in the world there is not even the least certainty.

It may exist, but it is not found among us in Pará.

To what, then, is the much-discussed unhealthy condition of the Amazonia reduced ?

To a climate immune from typhoid, scarlet fever, meningitis cerebro-spinal in epidemic form, all dangerous and very often deadly, and frequent in cold and temperate climates ?

To a climate almost unacquainted with diphtheria, as rare and mild in our midst as it is common to the children of cold climates in spite of the valuable curative serum ?

Knowing only the mildest form of pneumonias and of gripes ?

Without the numerous chirurgical forms of tuberculosis of malignant tumours, especially cancer, and of appendicitis ?

How many evils afflict us, and how many more devastate the civilised populations of the cold climates !

Yes, it is unjust and baseless, the charge against the climate of Amazonia and its sanitary conditions.

Neither Pará nor the Amazonas can be called the region of death.

In this most fertile land, equal to any, dwells a race strong and prosperous, prolific, intelligent and industrious, dominating uncultivated nature, attracting civilisation with open hospitable arms, capable of all undertakings, transforming in 10 years places like Belem and Manaos from small colonial settlements into fine, comfortable, and healthy cities.

As a proof of this, the pictures of Pará at our stand at the Exhibition were eloquent witnesses.

The population of this city is treble, and the same land is proud of possessing a valuable European contingent which numbers in Belem alone 300,000 inhabitants of different nationalities. A race displaying such aptitudes cannot but give a proof of the excellency of the country from where it sprang. And it is only justice to acknowledge and proclaim such a land as one most suitable for the development of mankind.

Dr. Antonino de Souza Castro,
Delegate of the State of Para and Municipality of Belem.

London, 1914.

THE REPUBLIC OF GUATEMALA.

In conjunction with a wealth of natural resources, progress has already brought Guatemala to that stage of advancement whence a rapid development of the country can be readily achieved in the near future.

AGRICULTURE. Considering the variation of climatic zones, it is not surprising that Guatemalan agricultural production is very varied. Coffee is of great importance. Next come sugar, cocoa, rubber, and tropical fruits, including the banana, in particular. Other products to which greater attention is being gradually given are tobacco, wheat, rice, and textile plants, such as henequen, izote, zapupe, etc.

Many other products could be cultivated with success, including indigo, sarsaparilla, vanilla, oats, barley Peruvian bark, cotton, balsam, beans, chile, cochineal, ramie, potatoes, etc. As regards fruits, the privileged soil of Guatemala produces and can produce, with great success, every variety known in the hot, cold, and temperate lands.

Of building timber and trees, there is a great and inexhaustible supply.

The following approximate calculation may be given of the areas under cultivation :—Coffee, 72,240 hectares ; maize, 96,600 ; sugar-cane, 33,600 ; banana, 14,700 ; beans, 8,400 ; cocoa, 6,300 ; cereals generally, 4,200 ; cattle-breeding estates, 357,000.

The sugar industry may eventually increase greatly, for the sugar-cane is of the best quality. The magnificent tropical fruits which Guatemala produces are admirably adapted for preserving and drying (an industry that is largely worked in the island of Cuba) and for exportation to Europe and to the United States.

Wheat grows well in the cold regions, as does barley ; cotton is produced with ease, as well as commercial fibres and tobacco.

MANUFACTURES. The manufacture of woven fabrics, the cultivation of cocoa, and proper utilization of the magnificent dye woods, will doubtless in time become important features of Guatemalan industry.

MINING. In addition to her agricultural advantages and manufacturing possibilities, Guatemala is one of the most promising of mining countries.

MEANS OF COMMUNICATION. Six important railway systems are now being worked in the Republic. The Central Railway, completed on January 19th, 1908, is one of the greatest achievements of the present administration. Its length is 196 English miles, between the capital, Guatemala City, and Puerto-Barrios on the Atlantic coast. The railway from the city of Guatemala to the port of San Jose on the Pacific, with a branch line to the important city of Mazatenango, was also opened during the present administration. The Western passes through Retalhuleu *via* Mulua and San Felipe, and terminates at Champerico, a large port on the Pacific. The Verapaz Railway connects Panzos and Pancajche. The Ocos Railway runs between that port on the Pacific and Vado Ancho, connecting at Ayutla with the Mexican National Railways. Finally, the Urban Railway serves the capital and surrounding districts. Within a few months the port of La Union in San Salvador will also be linked up by rail with the Guatemalan and Mexican systems.

The important roads are well kept, and there is a regular coach service between Guatemala City, Quezaltenango, and La Antigua, but a scheme is under consideration for the establishment of funicular railways, these regions being the highest in the Republic.

There is a direct steamship line from Puerto-Barrios to Liverpool, Hamburg, New Orleans, and New York, and there is also communication with the other Atlantic ports of Central America as far as Colon.

The American steamers running from San Francisco to Panama, and the vessels of the German Kosmos line, all call at the Guatemalan Pacific ports.

MUNICIPALITY OF ITAITUBA,

STATE OF PARA, BRAZIL.

AMAZONIAN RUBBER.

THE PRIME QUALITY IS THE RESULT OF THE SOIL.

To show the superiority of Amazonian Rubber and its superior quality over any other, better even than the advertising of it, there are the sundry articles manufactured with it, which keep in excellent condition twenty per cent. longer than those manufactured with rubber from other parts of the world.

No other country produces better rubber, not even other States of Brazil. In the same way that in Amazonia no tree transplanted from other countries gives as good fruit, so our Hevea takes its superiority from its native soil. This is due to geological formation, arranged by Nature in such a manner that the soil does not lose its oxygen and is always ready to receive the natural humus which the periodical flow of the river brings to the roots with the vitality which gives to the rubber a matchless elasticity.

Besides the geological nature of the soil, the torrential rains which fall for a period of three months and continue with less intensity for a longer period, must necessarily influence the great dampness of the soil, evaporating thus the mercury it contains.

Even in Amazonia we can see the different kinds of Hevea, each with its own special quality. As an instance of this assertion we have the rubber growing in Federal and Amazonian Area which is of superior quality to that growing in Pará.

There is no doubt that the Amazonas-sertao rubber has twenty per cent. more elasticity and more resisting power than the best Pará. This proves, therefore, that Amazonian rubber owes its superiority to the nature of the soil where it grows. In many States of Brazil, especially in Parahyba do Norte the hevea braziliensis has been planted, but the rubber extracted has not been of the same quality as that from Amazonas.

At the Fourth International Exhibition of Rubber, various specimens of rubber grown in different soils of the Amazon were shown, enabling people to see by comparison the variations in elasticity. Amazonian rubber can be classified thus :—

1. Amazonas-sertao.
2. Tapajos-sertao.
3. Tapajos and Xingu baixo.
4. Island and other producing States.

Every country has its geological formation and its climatic influence on the growth of some plant or other ; it is owing to this that Amazonia has its special tree—the Hevea. In Africa where the climate resembles ours, the Hevea and other trees of our forest are not to be found.

It could be said that chemical processes make all soils alike ; we do not deny it, but how long would such action last, and how much of the chemical preparation would be sufficient to make the soil produce the elasticity that is the special quality of Amazonian rubber ? And what would be the cost ? These are my questions ; let those who know answer them.

R. P. Brasil, *Mayor of Itaituba.*

London, June 26th, 1914.

STATE

OF

SAÕ PAULO

(BRAZIL).

COFFEE.

THE history of coffee goes back to remote times, and the first trace of it is ascribed to ancient Ethiopia. It was not known amongst Europeans until the latter half of the 16th century. In 1671, one of the Dutch Governors tried to acclimatise it in Batavia, and at the beginning of the 18th century unsuccessful attempts were made to cultivate it in Surinam. The first export was received by the Dutch from Java in 1719, and from that base the coffee plant was transplanted into the East Indies and Ceylon. It was the Dutch who introduced it into Europe as a beverage.

At the end of the 18th century coffee began to be grown in some of the Spanish-American Colonies. As far as Brazil is concerned, it was introduced in or about 1723 by Palheto, who brought the seeds from Cayenne, the first plantations being established in the Valley of the Amazon, Para, etc. The first coffee plants were introduced into SAÕ PAULO through the efforts of the then Governor General, Castro Mendonca ; but coffee had previously been popularised as a beverage by Father Manoel Jose. The success of the acclimatisation of the plant in the province of SAÕ PAULO, and the remunerative results of its cultivation, drew large numbers of agriculturists from all parts of Brazil, and the number of plantations went up by leaps and bounds. In the last few years of the last century the development of coffee cultivation in the State was enormous. Of the 171 municipalities which make up the State of SAÕ PAULO, 150 are producers of coffee on a more or less large scale.

To-day, coffee is the greatest source of wealth, the industry "par excellence" of SAÕ PAULO ; it is the "trust" of Brazil. It is a privilege of the State of SAÕ PAULO ; a privilege granted by Nature.

This precious plant is one of the most exacting, and will not yield its treasure in the greatest abundance unless its bed of mother earth be formed of the richest of material, rarely found in a state of Nature ; it must breathe a special atmosphere, at a certain height between sea and sky, and at a certain degree of division of heat, cold and moisture ; it needs plentiful supplies of water in Summer, and must nearly starve for want of it in Winter, if it is to put forth its golden harvest. These conditions and others as necessary are united in no part of the world so favourably as in this enviable and wide-spread corner of Brazilian territory. In Central America and other districts bordering on the Gulf of Mexico, the only rivals of SAÕ PAULO in the production of coffee, the plant only lasts for an average period of fifteen years, whilst in Sao Paulo one might almost call it a centenarian. In the districts mentioned only about half the number of coffee plants are planted on a corresponding superficial area, compared with what is planted in Sao Paulo, because there it is necessary to reserve nearly half the space for the plantation of rows of other species of shrubs for the protection of the tender coffee plant against the rays of the burning sun. In these countries each twig of coffee gives an average yearly yield of less than 1 lb. of coffee ; in SAÕ PAULO the yield is more than 1 kilogramme. In Central America, too, the crop is gathered berry by berry, the flower, the green fruit and the ripe fruit being nearly always found at one and the same time on the shrub, because of the difference between the seasons ; whereas with us it is only necessary to pass the hand along the branches to reap a hundredfold as much in the same time. This difference, amongst others, explains why, out of an average yearly production for the whole world during the past five years of 16 million bags of 60 kilos. each, thirteen millions of those bags are the produce of Brazil, and a bare three millions of the rest of the world. And of the thirteen million bags attributed to Brazil, ten come from the unequalled soil of SAÕ PAULO, the fertile region which has been entitled the Empire of Purple Land (l'Empire de la Terre Violette). These figures may appear enormous, but they are in no way exaggerated.

No more beautiful or inspiring rural scene could be presented than these interminable fields of coffee shrubs of Sao Paulo, following the graceful undulations of the country, and showing amongst the metallic reflections of the glossy pale green leaves the scarlet berries which leads one's thoughts on to the opening out of the generous red blood of the people of SAÕ PAULO themselves.

The coffee plant is one of those commercial plants of which nothing is lost. The wood makes very good firing, and may also be used in cabinet-making ; the leaves are used in several countries (particularly by the natives of the Sonde archipelago) for making an infusion which may be drunk like a sort of tea ; the pulp of the fruit furnishes alcohol of a very pleasant flavour, of which excellent liqueurs are made ; and finally, without mentioning the berries, of which the properties are too well known, the skin and residue of the fruit are rich in fertilising properties, and provide an excellent manure.

Daily experience, confirmed by the observations of science, prove that the consumption of coffee satisfies many needs of the human organism. In cold, wet climates, according to the distinguished French hygienist Michel Levy, coffee aids the systemto resist the depressing influence of the atmosphere ; in swampy districts it provokes and maintains the action of elimination by the skin ; in hot climates it also seems to act as a tonic to the digestive organs, and, by acting as a general irritant to the system, serves as a remedy in the collapses occasioned by excessive heat. In sea voyages and camp life it is a corrective of the preserved foods and vegetables which have to be consumed ; and serves many other good purposes in its character of a stimulant. It neutralises the effect of alcohol and of opium. Besides all this, it is an economical and nutritive food. A combination of coffee and sugar is a substantial, accommodating and heat-creating food. Coffee has also the remarkable property of sustaining the strength of those who have to undertake arduous work, and, being also economical, it has, therefore, been introduced on a large scale into the rations of the armies and navies of many countries.

Arabian coffee may be cultivated successfully between the parallels of 28° N. and 30° S., which mark the extreme limits of the existing plantations. Outside these limits isolated plants will grow in the open air, but not in bulk. In Brazil the shrubs will stand a low temperature if the air is calm. On the other hand, the shrub will stand heat up to 35° C., but beyond that the plant begins to suffer. In different districts the shrub appears to affect different altitudes. In SAÕ PAULO the elevation most suitable to its cultivation appears to be between 500 and 800 metres. Arabian coffee grows on hilly ground and on plains alike, especially on level tracts such as are found in SAÕ PAULO. The shrubs flower (sometimes three times) from August to December ; the blossoming season is early in the hotter regions, but late in the West and South West of SAÕ PAULO. The gathering of the fruit (or cherries) of the coffee plant begins in April, during the dry season. If that part of the year is rainy the planter suffers great loss, as the rain washes off the ripe fruit and much of it is lost. The shrub is also very sensitive to wind when it is constantly in the same direction. In the State of SAÕ PAULO the limit of cultivation is determined by the line of the white frosts in Winter, which varies considerably according to the altitude, and the more or less sheltered situation of the fields. The most successful cultivation is carried on within the limits of the temperate zone, which is also most favourable to European immigration. In SAÕ PAULO the districts devoted to coffee production are commonly known under the following names—roxa (red earth) ; masape, salmorao, catanduva, terra de areia (sandy ground) ; picarra, and pedregulho (rocky ground). The red ground is supposed to be best, and it is to this soil that is attributed, perhaps with a little exaggeration, the enormous production of coffee in this State. This soil is ferruginous and clayey, of diabasic origin, and of a dark red colour ; hence its name.

The coffee is dried in what is called a "terreiro," generally made of cement, but sometimes simply made of clay. It may be dried as a "berry" or as a "bean," both operations being carried on in the same terreiro or barn. The coffee beans are called "washed coffee," because the berries are first washed in a special machine. Washed coffee dries very rapidly, but it deteriorates more rapidly than the dried "coffee berries" which are better able to support variations of temperature. To prepare it for export the "washed" coffee is placed in a decorticator fitted with an exhaust ventilator, where it is deprived of the husk and passed straight into a sorting machine. The "berry" coffee passes through a greater number of operations to free it from impurities, and is finally placed in a machine which, by means of energetic friction, polishes the berries and frees them from the last traces of impurities ; all of which operations are automatic.

The coffee is then considered prepared for the market, but the most careful planters cause the berries to be again sorted in a machine which separates them according to shape and size. From this operation are obtained the various types of coffee known on the Brazilian market as "large Mocha," "small Mocha," "medium flat," "small flat," and "lowest quality."

COFFEE AS A BEVERAGE.

To drink good coffee it is absolutely necessary that the roasting of the beans, the grinding, and lastly, the infusion, should be carried out with the greatest care.

Of the two sorts of coffee roasters, the closed and the open, the former is generally employed by the trade and the latter in the home. It is of the utmost importance that the coffee should be roasted to the correct point, lest it should lose its flavour and also its important physiological properties. Besides caffeine, to which it owes its tonic properties, coffee contains nitrogenous substances, which are very nutritive, and essential oils, which give it its aroma. The nitrogen decomposes very quickly, and at a certain temperature the essential oils are completely volatilised. Therefore, the roasting must be carried out to a certain point, but must not pass it. In roasting, the berries lose from 16% to 20% of their weight, and their volume is increased about 30%.

When the coffee has been ground, the infusion should be made with a simple bag-strainer or by one of various kinds of filters. The bag should be of thick, close-grained cotton cloth, and must of necessity be small. After putting the coffee in the bag, pour boiling water over it, taking care to stir the mass of coffee with a spoon to help it to dissolve. The water becomes charged with the soluble substances, and is filtered through the meshes of the straining bag. It must be made with absolutely freshly-boiling water, because over-boiled water loses the air which it contains, and the coffee tastes flat. When the coffee is good and the infusion sufficiently strong it has a most agreeable aroma, and is the colour of very dark tobacco, with a golden shade round the edges.

In our opinion, the simplest and best of all coffee-pots is a white metal one, without any special strainer, but with the little cotton straining bag of which we have spoken, suspended in the interior near its mouth by a wire hoop. This also has the advantage of being cheap.

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THE BELGIAN CONGO.

PLANTATION RUBBER.

The introduction of the *Hevea* tree in the Congo dates from 1899. Fifty were then planted near Coquilhatville. This was increased later to 1,200 trees (1903) and to 2,970 trees in 1904.

Up to 1910 the large plantations of the Belgian Congo consisted, practically, of *Funtumia Elastica*. But, from that year onwards, the planting of *Funtumia* was almost entirely stopped, and *Hevea* propagated in all the State plantations.

Several series of tapping experiments were made in 1912 and 1913 on *Hevea* plantations belonging to the Belgian Government.

According to the yields obtained in the tests at Bakusu, Eala, Musa and Kutu, the following figures for annual yields seem to be justified for Central Africa :—

Hevea, ten to twelve years old, produce 400 to 600 kilos per hectare per annum (310 to 463 lbs. per acre).

Funtumia, six to nine years old, produce 150 to 200 kilos per hectare per annum (Sparano method) (132 to 176 lbs. per acre).

Funtumia, eleven years old, produce 100 kilos (about) per hectare per annum (Christy method) (88 lbs. per acre).

Funtumia, eleven years old, produce 50 kilos (about) per hectare per annum (Schultze method) (44 lbs. per acre).

The general conclusion arrived at, and resulting from experimenting in other equatorial colonies of Africa, is that the *Hevea* tree succeeds just as well as in Malaysia, gives a much better yield than that of the *Funtumia*, and seems, up to the present, in conjunction with the *Manihot*, to be the only rubber tree suitable for European plantations in Central Africa.

COTTON AND FIBRES.

In November last the Belgian Government, desirous of having definite information at the earliest possible moment on the subject of the quality and output of cotton in the Belgian Congo, engaged an American expert, Mr. Edm. Fisher, formerly an agent of the British Cotton Growing Association on the Gold Coast. This specialist is now engaged in making a comparison of the different varieties of cotton, American, Egyptian and Indian, at the Kitobola station, from seeds kindly supplied from the above-mentioned Association. The same experiments will be carried out next year at the Maniema, and the seeds of the harvests will be distributed amongst the natives of the Kasai and the Uele.

On account of the irregularity of the rainy season this year, sowing had to be repeated three times at Kitobola. This proves that in the Lower Congo the first part of the rainy season is subject to such irregularities that it is imprudent to commence sowing too early. It would be necessary to become acquainted, several years in advance, with the methods of cultivation, which necessarily vary from one district to another.

It is certain that there exist in the Belgian Congo vast regions capable of producing cotton of good quality, but whether it can be made profitable depends on two principal factors, *viz.*, the existence of a large native population, and less costly means of transport.

In this connection it is sufficient to mention, by way of example, the district of the Kasai, already irrigated by the river of the same name and by the Sankuru, which will eventually be crossed by the Lower Congo Railway line to Katanga ; the district of the Maniema, already served by the Great Lakes line, which will soon be connected up to the German line of Dar-es Salam ; the Kivu, which will be connected up with the same line by Lake Tanganyika ; and, finally, the Ituri and the East Uele, which will soon have economical transport to the Nile and Uganda. The two first districts we know by having travelled through them, and the two latter are known to be fertile and fit for white colonisation. They are also rich in cattle, which is an important point as regards the supply of manure and of draught animals.

The chief efforts of the Government will be directed towards the cultivation of cotton by the native population.

The Agricultural Department has also undertaken certain experiments in other textile plants, amongst which we may mention sisal in the first place. This plant grows very satisfactorily in the Lower Congo, and produces fibres from 1·20 to 1·50 m. in length, and of good quality. But, up to the present, the cultivation on a large scale has not been attempted in the Lower Congo.

Besides the two textiles mentioned, the Government has experimented with jute, ramie, the Urena lobata, the Callotropis procera, the textile banana, the kapok plant, and the Hibiscus cannabinus. The two latter, especially the Hibiscus, will be the object of special research, of which the results will be published later. There certainly exist in the Congo vast stretches of country where the Hibiscus could be cultivated by the natives.

Several kinds of fibres might be exported from the Colony. We might mention, for instance, the piassaba. There are several varieties of palms of the Raphia species in the Belgian Congo which are capable of producing piassaba. Certain of these palms are abundant in the great equatorial forest, and, to our own knowledge, particularly in the district of the Kasai, the Equator, the Bangalas, and the Oubanghui. At the mouth of the Congo, also, there is a species of Raphia vinifera which is also capable of producing piassaba.

We formerly despatched, from the district of the Kasai, some piassaba of very good quality, which would certainly be worth to-day 70 frs. per 100 kilos. At this price piassaba is worth exporting, and we are convinced that this industry could be developed amongst the natives. This particular piassaba was obtained from the stalks of the leaves of the Raphia palm, called on the Kasai, in the Luba tongue, " Mabondo," and which we believed to be of the same family as the Raphia Laurentii. The piassaba was obtained as follows. It is known that it is the stalk of the leaf, in the sheathed part, which is utilised for the preparation of piassaba. These stalks are steeped in water for eight days. They are then beaten with a hard wooden mallet in order to extract the fibres, which are thus separated from the surrounding tissue. Then the piassaba is washed in running water, and finally dried.

The difficulty will evidently be in inducing the natives to take up this industry. We are of opinion that the best way of attaining this end will be to establish markets where the natives can be assured of an outlet for the product at a reasonable price.

The same palms which produce piassaba could also yield raphia, which the natives use for the manufacture of certain cloths and plaited matting, which are sometimes of a very artistic design.

The kapok plant (*Eriodendron anfractuosum*) is also very plentiful in the Belgian Congo. The harvesting of this product should be a source of revenue for the natives, which ought on no account to be neglected. The Government have imported a great quantity of kapok seeds from Java. This kind is much more superior than the wild kapok, producing a better quality of fibre, and will be distributed amongst the natives. Just as with other products which require gathering, the difficulty lies in overcoming the apathy of the natives and inducing them to bring the product to market. The samples of kapok from the wild plants of the Colony have been valued, according to quality, at from 1 to 1·50 frs. the kilo.

The Botanical Garden at Eala has sent several consignments of fibres yielded by plants growing spontaneously in the Colony. Under this heading we have received fibres of the Urena lobata, Triumphetta semitriloba, Honckenya ficifolia, Cephalonema polyandrum, Sarcophrynium, Banana plantain, Celosia, Sanseviera, etc., all of which are still the subject of research.

A little-known textile plant, of which we have but slight information, is a plant of the family of the Euphorbia, the Manniophyton africanum. Long since travellers pointed out the textile nature of this plant.

The Manniophyton fulvum also yields a fibre of good quality, but less attention has been paid to this plant than to the first mentioned. It has, however, the advantage of growing in bush form, and it would be sufficient to sow very closely to obtain fibres of good quality. The plant grows in great abundance in the old native clearings of certain districts of Maiumbe. Experimental cultivation will be carried out by means of these two species.

The Manniophyton africanum is abundant in the Belgian Congo, especially in the wooded districts of the upper river. It is a creeping shrub, which sometimes attains a length of 30 to 40 metres and a circumference of 50 centimetres at the base. It is found most frequently in the glades and old clearings, sometimes even in the swamps. Certain officials have reported that, in the district of the Bangala, there are places where there are more than 50 bushes to the hectare.

The parts which are utilised are the young stalks, often very numerous, which are sometimes 3 to 5 metres long without branching. The natives say it is the young concealed stalk about 6 months old which yields the best fibres, and we have had personal confirmation of the truth of this statement. The old stalks only give a bark which is difficult to manipulate, the fibres of which are not tough. This plant is called by the natives N'Kose or Kossa.

The following is the method of preparing the fibre : The young shoots of about 1 metre long are taken. With the aid of a blunt knife the outer part of the bark is scraped off so as to remove the gummy matter and lay bare the fibres. The stalks thus prepared are then cut in two and bent inside out, which eventually facilitates the withdrawal of the fibres. These stalks are then dried in the sun for one day, after which the fibrous part can easily be removed by hand. The thongs of raw fibre thus obtained are again put to dry for two or three days. They are then collected into small bundles, which are beaten until each fibre is well separated. In this state it is ready for use.

The natives make from the fibre of the Manniophyton ropes of all sizes, which are very strong, and which are used for fishing lines, hunting nets, cables for canoes, hammocks, etc. The ropes used on certain plantations are made from the Manniophyton.

Recently we have received a quantity of samples of the fibres of the Manniophyton africanum, more or less well prepared.

A manufacturer, Mons. Paret Jette, of Brussels, has made many interesting experiments with this fibre. Samples of the fibre, and of cloth made from the raw material we sent him, were displayed at the Ghent Exhibition, and at the London Exhibition.

From a communication sent us by Mons. Paret we give the following information :—" The fibre of the Manniophyton africanum partakes of the nature both of hemp and of jute ; it shows the resistance to wet and the strength of hemp, and has the suppleness, fineness and silkiness of jute. It can be spun without the aid of oil, is easily bleached and coloured, and the thread obtained is very smooth. It can also be used for a number of purposes, such as sailcloth, furniture canvas, packing canvas, cable, rope, fishing line, etc., etc.

The manufacturer mentioned above is said to have invented a method, which he has patented, of extracting 50 per cent. of fibre from the dried bark.

The raw fibre, as prepared by the natives, contains a quantity of gummy matter, which has to be eliminated. Experiments are being carried out on the spot, and it is hoped to arrive at a satisfactory result.

The Kossa fibre forms the object of a trade carried on between the various tribes of fishermen of the Upper Congo. This trade is of little importance, but it is capable of development.

From information we have received quite recently from the district of the Bangala, the natives would consent to supply this fibre at from 20 to 25 centimes per kilogramme.

The two species of Manniophyton will form the object of special experiments in cultivation, and improvements in the method of preparing the fibre commercially will be studied on the spot.

The severe fall in price of India rubber draws more attention to the cotton growing experiments recently started on one of the Government's farms at Kitobola (Lower Congo).

Although cotton had been tried in the Congo for a number of years past, and was even cultivated on a small scale under the Portuguese in the West, and during the Arab slave-trade in the eastern provinces, the Kitobola experiments are the first conducted on a sufficient extent of land (50 acres) in really fertile soil and with the possibility of irrigation.

They are superintended by a well-known American expert, Mr. Edmond Fisher, who was for several years in the Gold Coast Protectorate, growing cotton in the rich alluvial soils that extend along the Volta River.

The lands of the agricultural experiment station of Kitobola are on the Lukunga river, 11 miles north of Tumba, a railway station at kilometre 187 on the narrow gauge line (2 ft. 6 in.) that connects the lower reaches of the Congo river with the Stanleypool and the extensive waterways of Central Congo.

A good road runs from Tumba to Kitobola, sloping downward all the way. The farm is built on the northern banks of the river ; above it tower the huge sunburnt hills of the Bangu range.

In this part of the Congo, at about 1,200 ft. altitude, the rains are heavier and more regular than at Boma and on the coast ; there is, nevertheless, a long spell of about 4 dry months, and in some years the length of the dry season exceeds 5 and even 6 months (1913–14).

Owing to this irregularity of the rainy season, early sowing is usually attended with much risk.

The grounds extend on both sides of the river, and the total area under crops and pasture averages about 250 acres of rich alluvial ground. There are 200 cattle on the farm, both native Angola breed and a cross of Angola and heavy Belgian bulls, the latter having a fairly good sprinkling of Shorthorn blood in their ancestry.

There are some very good cattle on the Kitobola farm, but they are often fly-struck, as the tsetse fly is rather common in the forest galleries along the numerous brooks and rivulets. The complete clearing of these woods is now in progress.

The principal crop grown at Kitobola is dry rice, one of the staple food crops in the Belgian Congo. Rice grown under irrigation was started two years ago, and has given very heavy yields. Mr. Fisher is making comparisons this year between American methods of rice growing and the Italian system now applied on the farm.

Cotton can, without any doubt, be grown very successfully on the farm, as fertile soil, farm manure, draught cattle and expert labour are available. Moreover, a large part of the farm is irrigable from a small dam on the Lukunga river.

The Kitobola trials, which have so far proved quite satisfactory, will be continued for several years, and Mr. Fisher will start another cotton experiment next season on the Government farm at Nyangwe (Upper Congo). In this former stronghold of the Arab slave-hunting chieftains, the Government keeps a herd of 500 cattle. There is no tsetse fly to be found for miles around the place, so that cattle-drawn ploughs and machinery will be available. About 125 acres of cotton, in several of the best varieties, will be grown at Nyangwe, in order to show the yield that can be expected with careful cultivation.

Cotton seed will be distributed freely among the natives of the district around Ponthierville, in order to start cotton growing amongst these agricultural tribes. They were formerly under the domination of the Arabs. Some of the Arab sultans have still real authority over the blacks. Cotton would be bought from the natives at about 1d. a pound, either by the Government or by a Belgian Cotton Growing Association.

A ginnery will be erected by the Agricultural Department in the vicinity of Stanleyville, where the seed cotton will be brought from Nyangwe, from the native farms along the banks of the Congo river, and along the railway ; also from the experimental Government Coffee Plantation at Lula on the railway (kil. 8).

Similar cotton growing experiments will be made at the end of this year in other districts of the Belgian Colony, and first in the thickly populated and well tilled country around Luebo, Luluabourg, Lusambo and Kabinda (Kasai and Upper Sankuru river). The native villages there average very often several thousands of people, all used to agriculture and growing very extensive fields of Sorghum (kaffir corn) and Maize.

Excellent work is being done in that line on the Kasai river by the American Baptist missionaries. They brought over from Texas several Texan agriculturists headed by Mr. Hillhouse, a man of considerable experience. His opinion about the possibilities of the Kasai district is highly favourable. He even compares it with Texas and believes that notable agricultural development will be effected in a few years. Mr. Hillhouse made some experiments this year on native and imported cotton.

Another tract of land where cotton could be grown at a profit and perhaps in notable quantities by the natives, is found along the Buta to Bambili motor traction roads and in Uele.

The cotton grown above Stanleyville will travel down river to Leopoldville on the Stanleypool (1,000 miles), then by rail to Matadi (245 miles), where it will be put on board the ocean steamers.

The freight and handling rates are still much too high, but will be lowered considerably before long. It is hoped that cotton could be sent from Stanleyville to Europe at 200 frs. (£8) per ton, this being still about double the expenses charged for American cotton from Memphis to Antwerp.

The expenses might be lowered still more if the Government would see its way to build, or support the building, of locks and lateral canals along the four big falls and rapids of the Lower Congo. According to an estimate by Mr. Wall, drawn up for Sir W. H. Lever, Bart., this canalisation could be done for a sum of about £50,000.

The economical effects of this huge work would be very great indeed, as the extensive lands of the Central Congo could then grow many different crops. It could even export its valuable timber, if cheap transport were obtainable.

Improved freight rates would tell immediately on the growing of cotton, coconuts, and cocoa, and on the exportation of palm oil.

TRANSPORT DEVELOPMENTS.

In a very few years, 8 or 10 at most, the centre of Africa (being practically the Belgian Congo) will be reached by fourteen railway lines :—

1. Five lines starting from the West Coast, respectively from Duala (Cameroun), Pointe Noire (French Congo), to Malange and the Congo Border (Angola), Matadi to the Katanga (Belgian Congo), Loanda and the Lobito-Bay lines, running to Katanga.

2. One line from Capetown, over Bulawayo, the Victoria Falls and Brokenhill to Elisabethville (Katanga-Belgian Congo).

3. Six lines, having their starting points on the East Coast, respectively at Beira (Portuguese Mozambique), Quilimane (Nyassa line), Dar-es-Salam (Tanganyika line, German East Africa), Kilimandjaro line (German East Africa), Uganda line from Mombasa (British East Africa), Sudan-line, from Port-Sudan, giving connection with the Nile and the Congo on Lake Albert Nyanza.

4. Two lines running from the Northern Coast of Africa towards the Congo river : the *Cape to Cairo Railway*, with its extension in the Sudan (Rail and Steamers), reaching the Congo border on the Nile at Lake Albert Nyanza ; and the projected Trans-Saharian *French line* from Algiers, towards Lake Tchad, the Ubangi river and the Congo.

These 14 railways will be linked together by the extensive waterways of Belgian Congo, that aggregate about 12,000 miles of magnificent rivers, navigable for steamers up to 500 and 1,000 tons. Several of these big rivers are still one or two miles broad at a distance of 1,200 to 1,500 miles from the sea. The Congo river itself is in some parts more than 10 miles broad.

About 200 steamers are plying now on these Central African rivers ; some of them are quite interesting and demonstrative of the spirit of enterprise shown by the Belgians.

A large steamer with Diesel oil motors and tunnel-screws is being erected now and will reduce by one-half the trip from Matadi to Stanleyville, the most central station in Africa.

A still faster boat, the "NETTA," left Antwerp at the end of June, fitted with electric searchlights, three separate engines and screws (100 H.P. each). This fast skimmer, drawing only 16 inches of water, is expected to run at a speed of 30 miles an hour, and cover the aforesaid trip in less than 6 days, viz., one-third of the time that is needed to-day to reach Stanleyville.

A grand work is projected in Lower Congo, the building of side-canals and locks along the Lower Congo river in order to enable medium-sized steamers (up to 1,000 tons) to run down from the centre of Africa to Matadi, where they will put their cargoes on board the ocean-going steamers.

The Katanga will soon be connected with the Nile (completing the Cape to Cairo line), and later with the Ubangi, and the projected Trans-Saharian line. When this French railway is completed, a traveller, starting from London or Paris, say on the Monday morning, will reach Stanleyville, the very centre of Africa, at the end of the same week, having travelled all the overland way in up-to-date dining coaches and sleeping-cars.

All along these Congo routes wireless stations keep in touch with friends in Europe. Twelve big wireless stations have been working in the Congo since 1912.

The remarkable results that are being obtained in Central Africa by British, French and Belgian activity, are well worthy of consideration ; it is plain now that Central Africa will develop much more rapidly than could have been anticipated, and that her great agricultural and mineral resources will before long be put to good account.

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By increasing or diminishing the quantity of this ingredient the process of coagulating is either quickened or retarded.

In order to make the rubber in this way a greater quantity of the coagulating ingredient would be necessary as owing to the latex being well preserved the ingredient would first have to neutralize the effect of the preservative before coagulation could be accomplished.

In the rubber forests where the latex is pure and contains no added preserving ingredient, only a small quantity is required for coagulation, which is more or less quickly obtained according to the amount used.

As in Brazil there is no immediate necessity to coagulate the rubber, this can be completely done within 24 hours with a very small quantity of the ingredient.

When coagulated, the rubber is brought under the pressure of a small cylinder in order to extract the serum and the water present in the ingredient, after which the rubber is ready for delivery, containing still a small percentage of water, however, which gradually evaporates until the rubber becomes completely dry.

Where drying apparatus exist, the rubber can be dried more quickly and be exported in a perfectly dry state.

Rubber retains for some time a certain percentage of water which, although disliked by the manufacturers, is the best means for conserving the superior power of resistance or "nerve," whereas completely dry rubber yields less resistance than that still containing some moisture.

The "nervic fibre" in rubber is best maintained by the presence of some water. Smoked Brazilian rubber balls preserve for a long time their resistant and elastic qualities, owing to the presence of water (serum) which is imprisoned by the concentrical layers and only disappears after some considerable time.

Just for that reason the thin smoked rubber sheets lose their resistant power more quickly as they get dry in less time.

My coagulating ingredient contains no organic or inorganic acid, thus the rubber treated with it is of the very first quality and always uniform, if one and the same latex is always employed.

The preservation and durability of the rubber made according to my process results from the constituent conserving substance included in my ingredient, which is such as exists in the smoke of nuts or kinds of timber used for smoking in Brazil.

Except for some of the evaporating elements contained in the smoke, and the organoleptic acids produced by the combustion of the fuel or by their presence with other constituent parts of the serum in the latex, my ingredient is in all ways similar to the principle of which the excellent quality of the Brazilian smoked rubber is a result.

The same result as is obtained by smoking latex with nuts or timber is obtained by my process, only that this process has the advantage of being a cold and rapid operation.

It is well known that heat dilates objects, and that by exposing rubber to heat, be it to the sun or to fire, the "nervic fibre" of the rubber is weakened, though not quite so much as by acid, but still to quite a disagreeably prejudicial extent.

For this reason my process, which replaces smoking and is liquid and cold produces a better effect with regard to the nervic fibre.

Differences in the resistance of Brazilian Rubber.

Everybody with some knowledge of rubber will have observed the differences in the resistance and shrinkage of the smoked Brazilian rubber. This has been proved by many tests on the part of manufacturers and chemists.

In the Amazonian forests there exist great varieties of "heveas," classified as well as unclassified, so that the collectors of rubber do not trouble themselves with separating the latexes from the different kinds of trees, a task almost impossible to them. Thus a latex mixture of different strengths is produced which affects the product to be prepared.

If there were no mixing, and the latex were of the true Hevea brasiliensis, the rubber produced would be of the very best quality possible, and without any rival as to its elasticity and resistance.

Where in mixtures the strong latex predominates the rubber still retains its great resistance and high elasticity. When, however, the latex contains larger proportions of the weaker latex, the rubber also loses part of its resistance and elasticity, and can even become weak or retain only a small amount of elasticity.

As the "nervic fibres" of these latexes vary in their resisting power, so rubber also varies much in this respect.

This is one of the principal causes of the different resistances noted in Brazilian rubber.

Another reason, no less important, for the decline in the resistance of the Amazonian rubber, is the addition of prejudicial substances to the latex. In their ignorance the rubber collectors make those additions in order to prevent the latex from coagulating before smoking is commenced and even during the lengthy time that smoking takes.

Solutions of potash, some of which are sold on the market under pompous names and advertisements, urine and many other substances are added to the latex in order to retard coagulation.

As my country is one of complete liberty, particularly regarding industries, no prohibitions exist, and the rubber collector can follow his work as he pleases. From this as well as from the differences of latex, results a diminution in the resistance of our rubber.

If only one quality of heveas existed in our forests, as is the case with the eastern plantations, and if the use of preparations detrimental to the "nervic fibre" were prohibited, the rubber produced would be uniform and always of even quality.

The daily growing competition of plantation rubber proves clearly to the Brazilians interested in this extractive industry, that they must amend these defects if they are to win on all points, provided the Oriental planters on their part bring their methods of cultivation and coagulating to perfection.

Since the inception of this industry, the smoking process has never been what one might desire, and the great trouble to which the collectors are put in keeping their laboratories provided with inflammable material and in being themselves exposed for many successive hours to the heat of fire and smoke containing substances harmful to the respiratory organs and eyes, should be completely done away with.

Furthermore, the three types of rubber which are produced by this method of smoking and sold on the market at different prices, increase the cost of production and reduce considerably the profit for the collector already heavily burdened with the dearness of provisions and frequent unjust classifications of his rubber.

Consequently the smoking of rubber in Brazil ought to be replaced by a method which, provided the product is of one and the same quality, would enable one to obtain only one type of rubber from all the latex collected.

This is the great problem of the Amazonian rubber industry.

I see no reason why one should try to smoke the latex produced on the rubber plantations which have been founded in the different parts of the Amazon.

The advantage of the trees being planted in lines, close to each other, enabling a single collector to tap 250 to 300 trees and to collect the latex, reduces already the cost of production.

The great sizes of the plantations are in themselves the largest drawback to the smoking process as done in Brazil, owing to the large yield of latex, and the double process of coagulating and smoking is absurd. After being coagulated the latex does not allow the substances of the smoke to penetrate the rubber. The smoke lends it colour as well as smell, but not quality.

To those who know what quantities of combustible material are required to smoke certain amounts of latex, it is clear that it is quite impossible for the planters of hevea trees in other countries than Brazil, to have the necessary material—nuts or special kind of fire wood—to smoke the enormous amount of latex that will be collected in the future. For instance, in order to smoke 12 litres of latex in the Amazonas one would require one rock oil tin (American) full of nuts. Only imagine the quantity of nuts necessary to smoke annually 280,000,000 litres.

According to some estimates the output from the plantations in 1915 will reach 110,000 tons of rubber, or 110,000,000 kilos. In order to produce this quantity of rubber at least 280,000,000 litres of latex are necessary. Where is one going to obtain sufficient nuts to smoke such a huge quantity of latex ?

The planting of palms means that one would have to wait about 10 to 15 years for the first fruits, of course a great drawback, and considering the expenses connected with the planting of sufficient palms to give annually this tremendous number of nuts, such a plantation must be considered chimerical indeed.

Instead of nuts, use is also made of chips of wood from certain trees which take 20 to 30 years before they mature, such as Pau d'arco, Massaranduba, Ttauba, Breu, Abiu and some others. Consequently it would be an absurdity to plant these, in order to fell them after 20 or 30 years and burn them. It proves that the latex of the plantation heveas can only be coagulated by means of chemical ingredients which effect the same result.

My chemical process produces rubber as good if not better than that which has been smoked. If you take some pure latex of the Hevea brasiliensis and prepare part of it by smoking and the remainder by my process, you will find that the latex is more resistant and contains less resin than that smoked. This has already been proved in 1909 and 1912 by some American manufacturers. The reason for this is to be found in the fact that my process is applied cold, and eliminates the resinous parts of the latex.

With regard to durability, indisputable evidence is furnished by the samples of rubber vulcanised by my process in 1909 in New Jersey, U.S.A. Although they are already five years old they are in perfect condition and the " nerve " unaltered, and it is worthy of mention that they were kept in a tropical climate, viz., that of Parà in Brazil. Further, I have the three pairs of gloves for surgery, which were prepared submerged in water in an American factory for the Rubber Exhibition of 1912, and which also were kept in the same tropical climate. If the rubber the gloves are made of were not of the very best quality, these delicate pieces of workmanship would have already been destroyed by such a hot climate. The rubber used was prepared according to my process and had been distributed for this purpose among the American manufacturers.

Finally I would like to say that I am at the entire disposal of any who would like to examine the rubber and articles (manufactured in 1909 and 1912) to which I have referred, and that I shall be pleased to demonstrate my process of rapid coagulation of not only Brazilian, but also of Oriental plantation rubber.

The following are the prizes awarded to my process :

Grand Prix. Rio de Janeiro Exhibition, 1908.
Gold Medal. Turin Exhibition, 1911.
Special Diploma. New York Exhibition, 1912.
Diploma of Honour. Rio de Janeiro Rubber Exhibition, 1913.

India Rubber World of North America, 1,000 dollar Silver Trophy for Best Process of coagulation of Hevea Latex. Fourth International Rubber Exhibition, London, 1914.

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Who's Who in the Rubber World .. ii.
Leyland and Birmingham Rubber Co., Ltd. .. iii.
Lewis & Peat .. iv.
French Occidental Africa .. v.
Sanitary Conditions at Para, Brazil .. vi., vii.
The Republic of Guatemala .. viii.
Municipality of Itaituba, Brazil .. viii.
State of Sao Paulo, Brazil .. ix., x.
Rubber, Cotton, Fibres Handbook .. xi.
The Belgian Congo .. xii., xiii., xiv., xv.
Dr. Cerqueira Pinto's Process for Making Rubber without Acid or Smoke xvi., xvii., xviii.
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